PL-TR-95-1042, Pt. 1

PL-TR-
95-1042
Pt. 1

PHASE II ENVIRONMENTAL BASELINE SURVEY OF McCORMICK RANCH, KIRTLAND AIR FORCE BASE, NEW MEXICO

Part 1 of 5

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31 January 1996

Final Report

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PL-TR-95-1042

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DRAFT SF 298

1. Report Date (dd-mm-yy)
31 January 1996

2. Report Type
Final Report

3. Dates covered (from... to)
Oct 93 - Jan 95

4. Title & subtitle
Phase II Environmental Baseline Survey of McCormick Ranch, Kirtland AFB, NM, Part 1 of 5

5a. Contract or Grant #
F29601-93-C-0219

5b. Program Element # 62601F

5c. Project # 9993

5d. Task # 00

5e. Work Unit # SE

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8. Performing Organization Report #

9. Sponsoring/Monitoring Agency Name & Address
Phillips Laboratory
3550 Aberdeen Avenue, SE
Kirtland AFB, NM 87117-5776

10. Monitor Acronym
SE

11. Monitor Report #
PL-TR-95-1042, Part 1 of 5

12. Distribution/Availability Statement Approved for Public Release; Distribution is Unlimited

13. Supplementary Notes Work done in association with Los Alamos Technical Associates

14. Abstract The Phase II EBS results document the extent of environmental contamination believed to be present on McCormick Ranch. Explosive test areas having the greatest potential for containing soil contaminants were identified using the following geophysical survey methods: EM 31 terrain conductivity meter, magnetometer/gradiometer, and ground penetrating radar. From the geophysical surveys five areas were selected to conduct further environmental analysis. A total of 310 soil samples were collected from the five areas and 13 specific high explosive test sites. The samples were screened for semi-volatile organic compounds, PETN, TNT, TNT-degradation products, nitrates and radioactivity. Laboratory analyses were performed and no explosives or degradation products were identified. Semi-volatile organic compounds were found in 2 samples, manganese was detected in 3 samples, nitrates were discovered below soil action levels and radiation levels were below background. Consequently, it is unlikely that significant contamination exists.

15. Subject Terms McCormick Ranch, Environmental Baseline Survey, Contamination

16. Report	17. Abstract	18. This Page	19. Limitation of Abstract	20. # of Pages	21. Responsible Person (Name and Telephone #)
Unclassified	Unclassified	Unclassified	Unlimited	200	Michelle Hedrick 505-846-4574

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AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
ANFO	Ammonium Nitrate and Fuel Oil
ASTM	American Society for Testing and Materials
BLEST	Berm Loaded Explosive Simulation Technique
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHEBS	Conventional High Explosive Blast Simulation
DABS	Dynamic Air Blast Simulation
DIP-5	Dihest Improvement Program Test No. 5
DNT	2,4-Dinitrotoluene or 2,6-Dinitrotoluene
DOE	Department of Energy
EBM	Enhanced Blast Munitions
EBS	Environmental Baseline Survey
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
FAE	Fuel-Air Explosive
GPR	Ground Penetrating Radar
HE	High Explosives
HEST	High Explosive Simulation Technique
ICP	Inductively Coupled Plasma
IRP	Installation Restoration Program
MDL	Method Detection Limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mHz	megahertz
mS/m	millisiemens per meter
MS/MSD	Matrix Spike/Matrix Spike Duplicates
MSM	Modular Storage Magazine
ND	None Detected (compound below method detection limit)
NMERI	New Mexico Engineering Research Institute
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PETN	Pentaerythritol Tetranitrate
PID	Photo-ionization Detector
PPM	Parts Per Million
PPT	Parts Per Thousand
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RDX	1,3,5-trinitro-1,3,5-triazacyclohexane
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigations/Feasibility Studies
SAL	Soil Action Level
SNL/NM	Sandia National Laboratories/New Mexico
SSTM	Standard Silo Test Mechanism

SWMU	Solid Waste Management Unit
SVOCs	Semi-Volatile Organic Compounds
TLC	Thin Layer Chromatography
TNT	Trinitrotoluene
USAF	United States Air Force
USCS	Unified Soil Classification System
USGS	United States Geological Survey

EXECUTIVE SUMMARY

This report presents the results of the Phase II Environmental Baseline Survey (EBS) of the McCormick Ranch explosives testing site, located on the southwest corner of Kirtland Air Force Base (AFB), Albuquerque, New Mexico. The study was performed by GRAM, Inc., with Los Alamos Technical Associates (LATA) as a subcontractor, for Phillips Laboratory under contract F29601-93-C-0219.

The McCormick Ranch site is leased by the U.S. Air Force from the New Mexico State Land Office, and the land is scheduled to be returned to the State following completion of environmental investigation. During World War II, the site was part of a large artillery impact area. From 1963 to 1992, McCormick Ranch was used by the U.S. Air Force and its contractors as a test range for small-scale high explosives (HE) development, analysis, and modeling.

The Phase I EBS (LATA, 1993) concluded that there is a potential for the existence of explosive or related compounds in the soil at McCormick Ranch because of the large number of HE tests performed and the multitude of conditions under which tests were run. The potential contaminants of highest concern were determined to be pentaerythritol tetranitrate (PETN), trinitrotoluene (TNT), nitrates, hydrocarbon fuels, and metals. The Phase I EBS concluded that the potential for contaminants in surface and near-surface soils to migrate downward to the water table is low. This conclusion is based on several factors: 1) the unsaturated zone beneath the site is over 300 feet thick; 2) evapotransporation has been determined to exceed precipitation in the area (Goetz and Shelton, 1990); and, 3) most of the contaminants of concern have low persistencies or low mobilities.

Field investigations were performed during the Phase II EBS to determine if contaminants are present in the soils at McCormick Ranch. Following a review of records, interviews with former site personnel, and field reconnaissance, the explosive test areas having the greatest potential for containing contaminants in the soil were identified. Key criteria established for this determination were the use of hazardous materials in the HE test, the size of the HE test, the depth of detonation, and the elapsed time since the HE test was conducted.

Geophysical surveys were performed in selected areas to more accurately locate the HE tests of interest. Three geophysical methods (magnetometer/gradiometer, EM 31 terrain conductivity meter, and ground penetrating radar) were used to locate buried objects and disturbed soils related to explosives testing. The geophysical surveys were performed in five selected areas:

four with dimensions of 500 by 500 feet, and one with dimensions of 400 by 500 feet. The geophysical surveys identified abundant buried debris, including ferrous metal, non-ferrous metal, and non-metallic objects. In addition, the geophysical surveys identified covered subsurface depressions (e.g., trenches or craters) and conductive soils.

Trenching and soil sampling were performed in four locations where evidence of subsurface tests had been identified by the geophysical surveys. Abundant test debris (including wood, concrete, rebar, cables and wire) was encountered in the trenches. In addition to trenching, hand augering and soil sampling were performed in 13 HE test areas. A total of 310 soil samples were collected from the four trenching areas and 13 hand augering areas. All samples were collected at locations of historic explosive testing, where soils were determined to have the greatest potential to contain contaminants.

Soil samples were screened at a field laboratory for semi-volatile organic compounds (SVOCs), PETN, TNT, TNT-degradation products, nitrates, and radioactivity. Field screening identified SVOCs in seven samples, nitrates in 245 samples, no explosive compounds, and no radiation above background levels.

Laboratory analyses were performed on selected soil samples, and no explosives or explosive-degradation products were identified. However, a plastic cord filled with approximately two grams of powder consisting of RDX was found in Trenching Area 2, the location of a High Explosives Simulation Technique (HEST) test. Naphthalene and phenanthrene were detected in two soil samples collected in Trenching Area 2. The SVOCs are probably related to wood preservatives from a burned railroad tie that was present near that sampling location. Phthalate was detected below the Practical Quantitation Limit in one sample at the Generator Site. It is likely the SVOC was introduced from the plastic bag that was used as the soil sample container. With the exception of manganese in three samples from Trenching Area 2, the concentrations of metal constituents were below published Soil Action Levels. Nitrate concentrations were below Soil Action Levels in all soil samples. No radionuclide concentrations or radiation levels exceeded background in the soil samples.

A regional and site hydrology study was conducted as part of the Phase II EBS (Attachment 1). Water level measurements were made in five on-site monitoring wells, which were previously installed at the site by the U.S. Geological Survey for the Kirtland AFB Installation Restoration Program. Water levels in these wells are between 350 and 380 feet below ground surface. The groundwater flow direction at the site is to the north-northwest. Recharge of the groundwater

from the surface is probably minimal because evapotranspiration rates are estimated to exceed precipitation rates in the area (Thorn et al., 1993), and there are no surface channels at the site to concentrate runoff. Therefore, past site activities conducted at the surface or near-surface have probably not resulted in the migration of contaminants into the groundwater.

The site selection process identified the HE test areas of greatest concern at McCormick Ranch, and soil samples were collected in all of those areas during the Phase II EBS investigation. Phenanthrene, naphthalene, a plastic cord containing RDX, and manganese with concentrations exceeding soil action levels were identified in Trenching Area 2, an area where debris had apparently been disposed and burned. No other contaminants were found in the soils at the HE test areas that were investigated. Because only minimal soil contamination was found in the HE test areas of greatest concern, it is unlikely that significant contamination would be found in soils at the remaining HE test areas of lesser concern.

1.0 INTRODUCTION

This report presents the results of the Phase II Environmental Baseline Survey (EBS) of the McCormick Ranch site, Kirtland Air Force Base (AFB), New Mexico. The Phase II EBS Report is an addendum to the Phase I EBS Report (LATA, 1993), and was prepared by GRAM, Inc., with LATA as a subcontractor, for Phillips Laboratory under contract number F29601-93-C-0219.

1.1 Purpose and Scope

The McÇormick Ranch site is leased by the United States Air Force (USAF) from the New Mexico State Land Office, and the land is scheduled to be returned to the possession of the State. USAF policy states that an EBS must be conducted to determine the condition of real property that is to be acquired, transferred, leased, sold, or otherwise conveyed. As a result, an EBS of the McCormick Ranch site was conducted to meet the following requirements (USAF, 1994):

- Document the nature, magnitude, and extent of any environmental contamination of the property;
- Define the potential environmental contamination liabilities associated with the property;
- Develop sufficient information to assess the health and safety risks associated with the property, and ensure adequate protection of human health and the environment;
- Provide the basis for notice, if required, under Section 120 (h)(1) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9620 (h)(1); including identifying the type, quantity, and time-frame of any storage, release, or disposal of hazardous substances on the property.

The McCormick Ranch site has been identified as an Appendix I site in the Kirtland AFB Resource Conservation and Recovery Act (RCRA) Part B Permit that was issued by the United States Environmental Protection Agency (USEPA) on October 10, 1990. The EPA has designated the site as a Solid Waste Management Unit (SWMU #6-31), and the site has been incorporated into the Installation Restoration Program (IRP) as Site OT-28 (USGS, 1993b). The Kirtland AFB IRP is responsible for the overall identification, investigation, and restoration of sites that pose a threat to public health, welfare, or the environment.

The McCormick Ranch EBS was performed in conjunction with a real estate transaction to establish the current environmental condition of the site. Any contamination found to exist as a result of this EBS will be considered for remediation under the IRP, as appropriate.

The Phase I EBS concluded that contaminants may be present in the surface and near-surface soils at the McCormick Ranch site as a result of high-explosives (HE) tests that were conducted from 1963 to 1992 (LATA, 1993). The Phase II EBS was performed to determine if any explosive residues, detonation products, decomposition products, or other related materials are present in the soil and are hazardous. The Phase II EBS sampling was limited to surface and near-surface soils for the following reasons:

- The Phase I EBS determined that contaminants would most likely be contained in the surface and near-surface soils, because, with the exception of two tests (DIP 5 test at a depth of approximately 250 feet; HEST at a depth of approximately 30 feet), all tests were conducted within 15 feet of the ground surface;
- Groundwater is at a depth of greater than 350 feet beneath the site, and evapotranspiration exceeds precipitation in the area (Goetz and Shelton, 1990); meaning that most, if not all, of the precipitation falling on McCormick Ranch is likely to evaporate rather than infiltrate through the vadose zone to the water table. As a result, it is unlikely that any contaminants have migrated by means of aqueous transport through the vadose zone and into the underlying aquifer;
- The Kirtland AFB IRP is responsible for conducting sampling and analysis of groundwater beneath and adjacent to the site.

Therefore, the focus of the Phase II EBS investigation was to identify the types and concentrations of contaminants present in the soil, and to document the areas of contamination, if any. The Phase II EBS field investigation at McCormick Ranch included: 1) geophysical surveys to identify HE test locations; 2) trenching, hand-augering, and soil sampling in areas of greatest concern; 3) surface water sampling; 4) field screening for TNT, nitrates, PETN, semi-volatile organic compounds (SVOCs), and radiation; and 5) laboratory analysis for contaminants of concern (including radionuclides). A study to evaluate local and regional hydrogeologic conditions was also conducted for the purpose of evaluating the potential for the presence of contaminants in the vadose zone and groundwater, and is presented in Attachment 1.

This report is an addendum to the Phase I EBS Report (LATA, 1993), and presents the activities and findings of the Phase II EBS investigations at the McCormick Ranch site. It includes a description of the field methods used to evaluate the nature and extent of contamination at the site, a summary of the analytical methods used for field screening and laboratory analysis, and the results of the field investigations and sample analyses. The report concludes with a summary description of the soil contamination encountered at McCormick Ranch during the Phase II EBS investigation.

1.2 Site Description

1.2.1 Site Location

Kirtland AFB is located southeast of, and adjacent to, the city of Albuquerque in central New Mexico (Figure 1.1). The McCormick Ranch site is leased by the Department of the Air Force, Kirtland AFB, New Mexico from the Commissioner of Public Lands, New Mexico State Land Office. The approximately one square mile test site is located immediately west of the southwest corner of Kirtland AFB, New Mexico in the north half (N1/2) of Section 1, Township 8 North, Range 3 East (approximately 427 acres); and in the south half (S1/2) of Section 36, Township 9 North, Range 3 East (approximately 320 acres). The McCormick Ranch site is bordered on the north by the Department of Energy (DOE) buffer zone, on the east by Kirtland AFB, on the south by the Isleta Pueblo, and on the west by the proposed Mesa Del Sol development area.

1.2.2 Site Environment

The elevation of the McCormick Ranch site is between 5,250 feet and 5,280 feet above mean sea level. The near surface geology consists of three to six feet of colluvium (eolian sands and silts intermixed with colluvium gravels) covering Cenozoic alluvial basin-fill deposits that are approximately 5,000 feet thick (Hawley and Haase, 1993). Several soil types have been identified on the site during archaeological surveys, including sandy loam soils and the Pajarito (PAC) and Madurez (MaB) loamy fine sand series (Center for Anthropological Studies, 1981). The land surface has a one to two percent downward slope to the west.

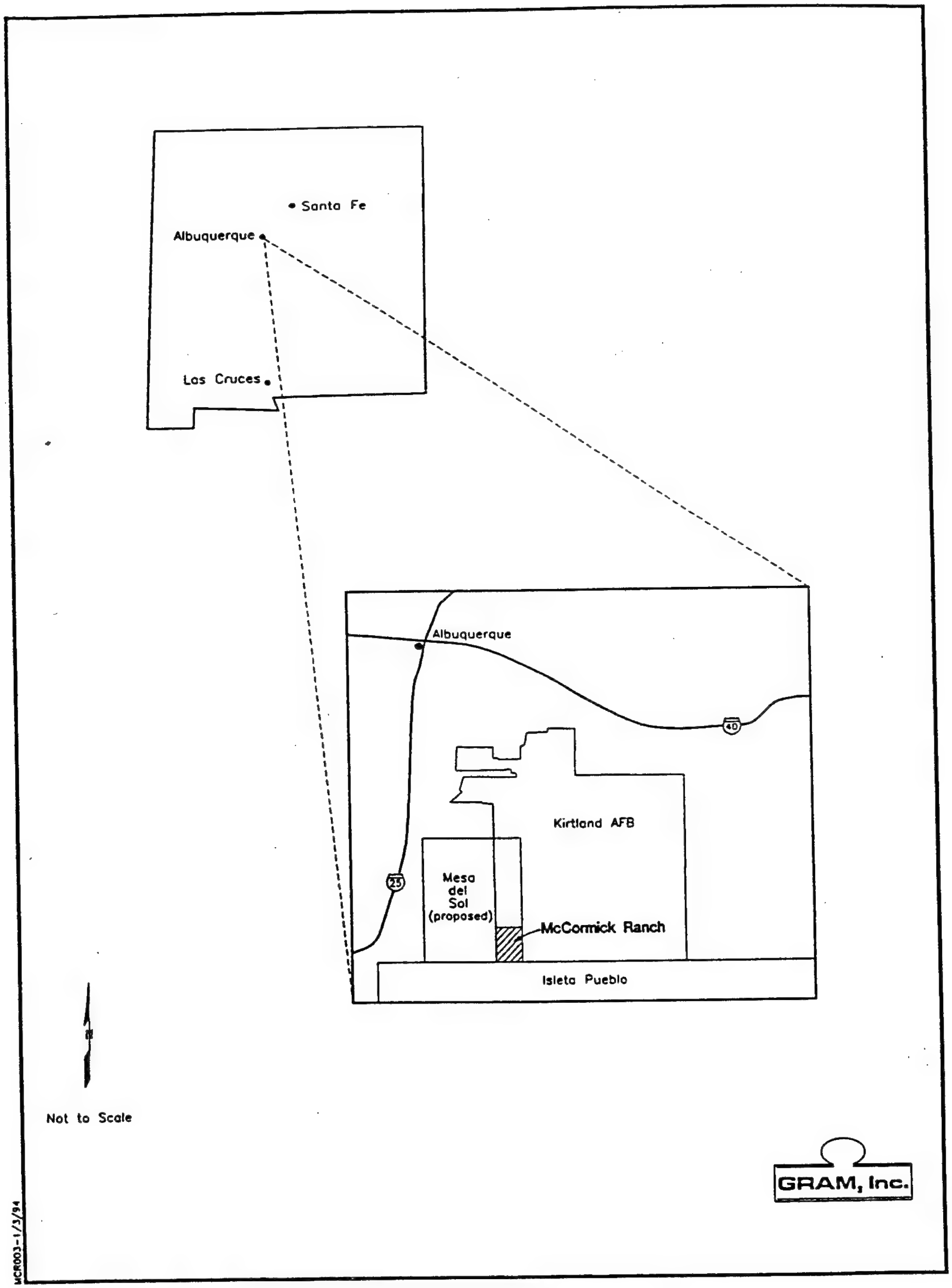

Figure 1.1 General Location of the McCormick Ranch Site, Kirtland AFB, New Mexico

The climate of Kirtland AFB and vicinity is classified as "arid continental." Mean annual precipitation is 8.4 inches (at Albuquerque International Airport). Average monthly precipitation in the Albuquerque area ranges from less than one inch during November through March to more than 1.25 inches in July and August. Winter months are typically dry and monthly snowfalls seldom exceed three inches (approximately 0.25 inches of water). Snow rarely lasts longer than 24 hours in the non-mountainous areas. Typically, almost half of the annual precipitation occurs during the summer months in the form of brief but locally heavy scattered thunderstorms. Prolonged periods of continuous precipitation are rare.

The mean annual maximum temperature at Kirtland AFB is 69 degrees Fahrenheit, and the mean annual minimum temperature is 44 degrees Fahrenheit. The highest mean maximum temperature is 91 degrees Fahrenheit in July and the lowest mean minimum temperature is 24 degrees Fahrenheit in January.

The prevailing wind direction from May through October is from the south or southeast, and the mean wind speed is seven to nine knots. From November through April the prevailing wind direction is from the north or north-northwest, and the mean wind speed is six to nine knots (USAF Installation Restoration Program, 1993).

Water levels measured from the USGS monitoring wells at McCormick Ranch during the study were between approximately 350 feet to 380 feet below ground surface. Actual evapotranspiration (evaporation of water from the soil surface, transpiration of water from the soil by plants, and evaporation from leaves of plants) has been estimated to be about 95 percent of precipitation in this climatic regime. The remaining five percent is divided equally between runoff and recharge (U.S. Army Corps of Engineers and others, 1979). However, a study by the United States Geological Survey (USGS) in nearby areas showed that the potential evapotranspiration exceeds the annual rainfall by several inches (Goetz and Shelton, 1990). This study suggests that, under normal conditions, it is unlikely that rainfall recharges the water table aquifer in the McCormick Ranch area.

There are no perennial surface waters in the vicinity, and no arroyos within one-half mile of the McCormick Ranch site. The southern part of the site has been identified as a dry playa that is underlain by unconsolidated sand and clay. Based on the surface contours shown on the USGS Hubble Springs 7 1/2-minute topographic quadrangle map (USGS, 1974), the playa could hold runoff from the east and allow the runoff to spill offsite during and after intense precipitation (abnormal conditions). However, because of the extensive excavating, grading, and soil

reworking activities that have taken place at McCormick Ranch since the publication of the USGS map, the playa has been altered from its natural state. Surface water ponding in the playa is now primarily limited to trenches, craters, and other man-made depressions. Several small ponds (approximately 50 feet in diameter and two feet deep) were present in the playa when trenching and soil sampling activities started on August 24, 1994. By the time sampling activities concluded on September 19, 1994, the ponds were dry.

1.2.3 Site History

From the turn of the century until World War II, McCormick Ranch was used for livestock grazing. During World War II, the McCormick Ranch site was used as an artillery impact area. Unexploded artillery rounds and projectiles are still occasionally found at various locations at the site (Ken Bell, personal communication, November 1992). Since 1963, the McCormick Ranch site has served as a test range for small-scale, HE testbed development, analysis, and modeling.

High explosives testing activities at the McCormick Ranch site have included the use of a wide variety of explosives, initiators, co-detonation compounds, and associated test materials. A list of the explosives and some co-detonation compounds, along with relevant physical and chemical characteristics, is presented in the Phase I EBS Final Report (LATA, 1993).

1.3 Previous Site Environmental Investigations

1.3.1 Phase I EBS

A Phase I EBS of the McCormick Ranch site was conducted by LATA, and the Phase I EBS Final Report was completed in June, 1993 (LATA, 1993). The Phase I EBS evaluated the potential for contamination at the site based on a review of documents, personal interviews, site maps, and site reconnaissance. The Phase I EBS concluded that HE testing activities may have introduced contaminants into the soils at the site. The primary potential contaminants of concern were determined to be pentaerythritol tetranitrate (PETN), trinitrotoluene (TNT), nitrates, metals, and hydrocarbon fuels.

1.3.2 Installation Restoration Program (IRP) Investigations

A study of soil and groundwater beneath the McCormick Ranch site was conducted by the USGS as part of the RCRA Facility Investigation (RFI), Stage 2A, at Kirtland AFB for the IRP. Five monitoring wells (KAFB-1001 through KAFB-1005) were installed around the perimeter of the site by the USGS for the RFI investigation to assess the impact of site activities on groundwater. Water samples from the five wells were collected in April, 1993. These water samples were analyzed for volatile organic compounds (VOCs), explosive compounds, metals, cations, anions, dissolved and suspended solids, and total petroleum hydrocarbons (TPH). Analytical results from the USGS groundwater sampling are available in the data report for the investigation (USGS, 1993a), and are not presented or evaluated in this report.

2.0 FIELD PROGRAM AND DATA COLLECTION

The Phase II EBS field investigation at McCormick Ranch included: 1) geophysical surveys to identify HE test locations; 2) trenching, hand-augering, and soil sampling in areas of greatest concern; 3) surface water sampling; 4) field screening for TNT, nitrates, PETN, semi-volatile organic compounds (SVOCs), and radiation; and 5) laboratory analysis for contaminants of concern (including radionuclides). A study to evaluate local and regional hydrogeologic conditions was also conducted for the purpose of evaluating the potential for the presence of contaminants in the vadoze zone and groundwater, and is presented in Attachment 1. A description of the geophysical survey, trenching, hand-augering, and soil sampling are contained in this Section and results of these activities are presented in Section 4.0. Procedures for field screening and laboratory analyses are discussed in Section 3.0, and results of these activities are presented in Section 5.0.

2.1 Geophysical Surveys

A geophysical site selection process was used to focus geophysical investigations on areas that are more likely to have contamination due to HE tests. For the purpose of Phase I and Phase II EBS, "areas of greatest concern" are those areas where the largest HE tests were conducted in the past. This process resulted in the selection of five areas that encompassed the majority of the larger HE tests conducted at the site. Because the exact locations of some of the tests within the five areas were not known, geophysical surveys were performed to pinpoint the test locations. Geophysical surveys were not performed in areas where tests were either accurately mapped, or located during field reconnaissance by GRAM and LATA personnel.

2.1.1 Selection of Geophysical Survey Areas

To select areas for geophysical surveys, the history of HE testing at McCormick Ranch was reviewed and the information from the Phase I EBS Report was evaluated. The field locations of HE tests selected for geophysical investigation were identified either from estimated or surveyed locations on New Mexico Engineering Research Institute (NMERI) maps, or they were identified during site visits by people who had first-hand knowledge of test locations (Figure 2.1). The approximate locations of many tests were often evident in the field by the presence of shallow craters with radial fractures, well casings or other test debris, and/or disturbed soils. Five survey

areas were then selected for geophysical investigation (Figure 2.1 and Plate 1). The dimensions of the five areas were chosen to encompass all or some portion of the selected HE tests. An additional geophysical survey was conducted at the Gravel Pit Area, where it was suspected that test debris (including metal plates, concrete, wiring, cables, and spools) had been buried.

2.1.1.1 Selection Criteria

An analysis of the HE testing at the site was conducted to identify test areas with the highest probability of containing soils with explosives residues or other contaminants of concern. The criteria used to rank the tests were:

- Use of potentially hazardous materials in the test (e.g., TNT, PETN, fuels),
- The size of the test (i.e., the amount of hazardous materials used),
- Known buried structures, metal debris, or covered trenches associated with the test,
- Subsurface detonation of explosives during the test, and
- Elapsed time since the test was conducted.

To maximize the amount of information collected from the geophysical investigation, survey areas were selected to encompass multiple HE tests where large quantities of potentially hazardous materials were detonated underground. Subsurface tests were selected because materials remaining underground would be less likely to have completely degraded in the years since the tests. Further information on the geophysical site selection process is available in the Addendum to the McCormick Ranch Phase I EBS Report (GRAM, 1994a). Table 2.1 lists the tests, test materials, burial depths, and dates of testing for the HE tests covered in the five geophysical survey areas. The Gravel Pit Area, which was also investigated using geophysical methods, was not the site of any recorded HE testing but was investigated because it was reportedly used for the disposal of test debris.

2.1.2 Geophysical Methods

Geophysical surveys were performed in the five areas selected, and in the Gravel Pit Area, to identify disturbed soils (covered trenches and craters) and buried debris related to explosives testing activities. Initial surveys were performed in the five areas with a Geonics Model EM 31 Terrain Conductivity Meter (EM 31), and a Gem Model GSM-19 Magnetometer/Gradiometer Instrument, with readings taken every five feet on north-south traverses spaced ten feet apart.

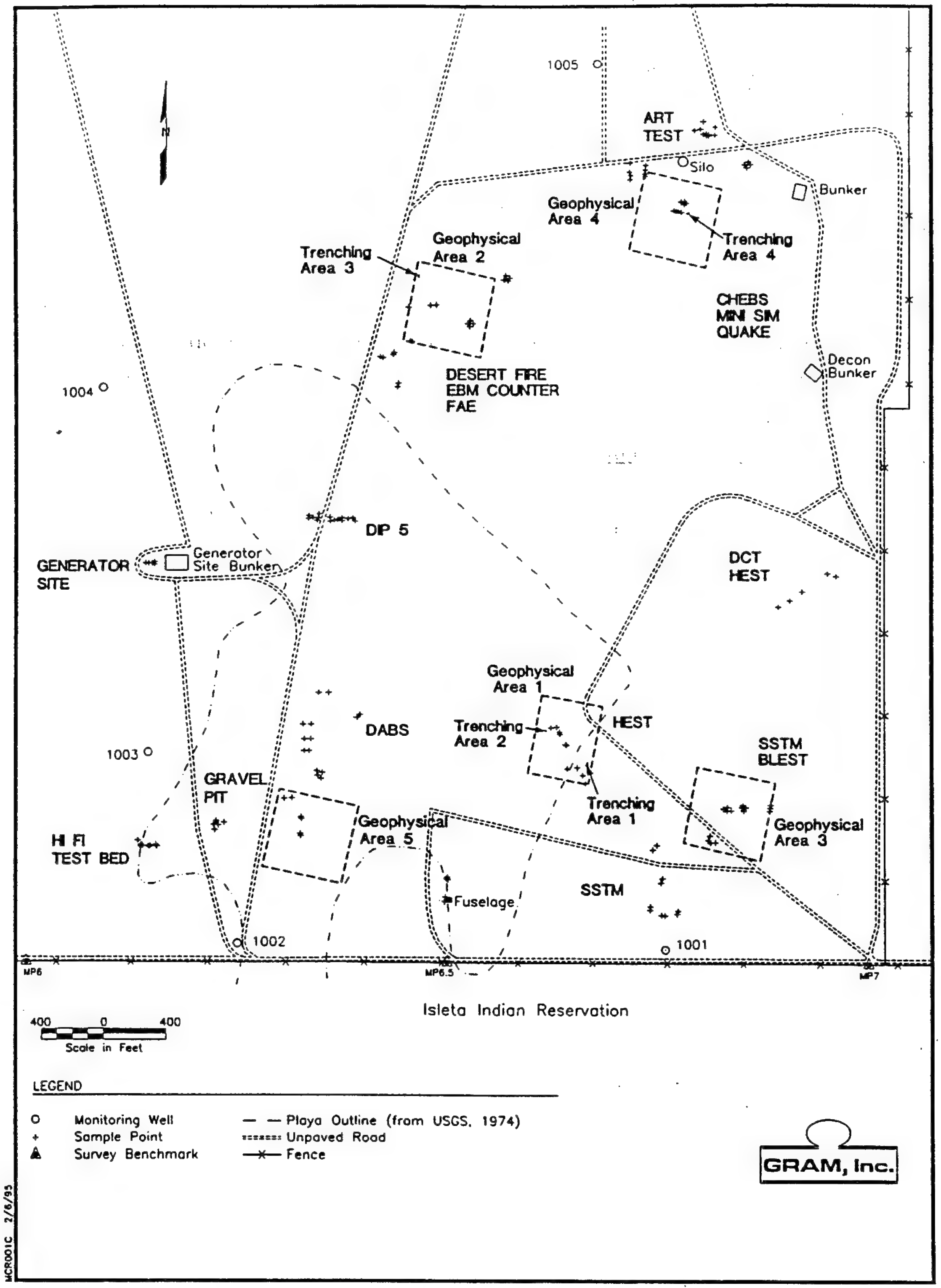

Figure 2.1 **Locations Geophysical Surveys, Trenching Areas, and Hand-Auguering Areas**

Table 2.1 HE Testing and Test Materials Used in the Geophysical Survey Areas

AREA	TESTS	MATERIALS USED	BURIAL DEPTH	DATE
1	High Explosive Simulation Technique (HEST)	>20,000 Pounds PETN, Concrete, Wire, and Wood	10-30 Ft.	1966
2	Desert Fire, Event Series, Enhanced Blast Munitions (EBM), Counter Fuel-Air Explosive (FAE), Modular Storage Magazine (MSM)	TNT, PETN, Fuel Oil, Other Volatile Organic Compounds, Metal Debris	Surface, Shallow Subsurface	1984-1992
3	Standard Silo Test Mechanism (SSTM), Berm Loaded Explosive Simulation Technique (BLEST)	PETN, TNT, Fuel Oil, Steel, Concrete, Wire	16-28 Ft.	SSTM:1985-1986 BLEST: 1967
4	Conventional High Explosive Blast Simulation (CHEBS), Mini Sim-Quake, Bomb Tests	>70 Tons of TNT, Fuel Oil, and Metal Containers (Mini Sim-Quake), TNT Bombs, PETN, Fuel Oil (Chebs, Bomb Tests)	Approx. 10 Ft.	CHEBS: 1984 Mini Sim-Quake: 1977 Bomb Tests: 1990-92
5	Dynamic Air Blast Simulation (DABS)	PETN, TNT, Fuel Oil, Metal; Conducted in Concrete Lined Trenches	Surface, Shallow Subsurface	1975-1985

Following completion of these surveys and data interpretation, a Geophysical Survey Systems, Inc. (GSSI) SIR-10 digital ground penetrating radar (GPR) instrument was used to further define targets identified using other methods. Field operating procedures, calibration, quality assurance/quality control (QA/QC), and data collection activities are discussed in the Work Plan for the geophysical investigation (GRAM,1993). Discussions of each of the geophysical methods used in the surveys are presented in the following sections. Results of the geophysical investigations are presented in Section 4.1.

2.1.2.1 Magnetometer/Gradiometer Instrument

The Gem GSM-19 magnetometer/gradiometer instrument measures the total intensity of the magnetic field and the vertical gradient of the total magnetic field. The term "total magnetic field" refers to the sum of all vectors of the field, as opposed to a single component vector (e.g., vertical flux). Total magnetic field and vertical gradient measurements detect buried ferrous metal such as steel and iron. Magnetic measurements cannot be used to locate brass, aluminum, copper, or most types of stainless steel. Instrument response depends upon the burial depth and mass of the ferrous target. Tests have shown that a single 55-gallon drum can be detected at a burial depth of 22 feet with total magnetic field measurements, and at a depth of 15 feet with magnetic vertical gradient measurements (Gilkeson and others, 1992).

Total field measurements must be corrected for variations in the ambient field (diurnal variations, micropulsations, and magnetic storms) over the course of the survey. This was accomplished by synchronizing field readings with readings at a fixed base station. Base station readings were electronically subtracted from field readings taken at the same moment in time, removing the effects of changes in the ambient field. Vertical gradient measurements do not require this correction, as they are derived from two simultaneous measurements at different heights above the ground. Total field measurements have a greater depth of detection than vertical gradient measurements, but have lower target resolution. For this reason, both types of measurements were made at each point on the survey grids.

2.1.2.2 EM 31 Terrain Conductivity Meter

The Geonics Model EM 31 instrument measures apparent conductivity of materials (quadrature output) and detects buried metal (in-phase output). Quadrature output values measured with the EM 31 instrument are called apparent conductivity values, because they represent a composite conductivity value for materials within the range of detection by the instrument. For surveys at McCormick Ranch, the instrument was operated with horizontal coils (vertical dipole), providing a total depth of response of 18 feet and the depth of major response of five feet below the instrument. The quadrature output provides direct readings in milliSiemens per meter (mS/m). The in-phase output of the EM 31 instrument detects all types of metal (including non-ferrous metals), and the response is related to burial depth and surface area of the target. Tests have shown that, under ideal conditions, a single 55-gallon steel drum can be detected with EM 31 in-phase measurements at a burial depth of ten feet (Gilkeson and others, 1992).

2.1.2.3 Ground Penetrating Radar

Ground penetrating radar instruments transmit short pulses of electromagnetic energy (in the radar frequency range) into the subsurface and measure the resulting reflected energy. Energy is reflected at interfaces where there is a change in electrical properties (dielectric permitivity and/or conductivity) of subsurface materials. Reflective interfaces are generally caused by changes in grain size, moisture content, and composition of soils and pore fluids. Void spaces, buried metal objects, and other types of buried debris also reflect electromagnetic energy, and are often identified using the GPR method.

The penetration depth of the GPR signal depends upon the frequency of the signal and the conductivity of subsurface materials. Resistive materials provide the greatest signal penetration, and in highly conductive soils penetration of the GPR signal may be limited to a few feet. Low-frequency signals penetrate more deeply than high-frequency signals in a given soil material. However, high-frequency signals provide better target resolution because they have a shorter wavelength. For this reason GPR surveys at McCormick Ranch were performed with both 100 and 300 megaHertz (mHz) antennas to optimize penetration depth and target resolution, respectively. Surveys were performed with a GSSI SIR-10 instrument, which is a digital color GPR system with advanced filtering and data processing features. Continuous transects were collected over buried targets identified during the EM 31 and magnetic surveys.

2.2 Trenching and Hand Augering

HE test areas with the greatest potential for containing contaminants in the soil were identified using information obtained from the geophysical surveys, historic data compiled during the Phase I EBS, interviews with persons formerly associated with testing at the site, and site visits. Four underground HE test locations were selected for trenching and soil sampling. Thirteen areas encompassing surface and underground HE test locations, along with potential hazardous materials release sites and debris disposal sites, were selected for hand-augering and soil sampling. Two off-site soil sampling locations, not believed to be impacted by HE testing, were also selected to provide data for comparison. The sampling strategy ensured that the largest subsurface HE tests documented and located at the site were evaluated in-depth through trenching. In addition, the collection of hand-auger samples at selected surface and subsurface test locations ensured that a broad area of the site was investigated. A large number of soil samples collected during trenching and hand-augering were located within or directly adjacent to the playa that was identified on the USGS topographic map (USGS, 1974). The playa area is of interest because surface runoff may accumulate within this area and concentrate contaminants which may be carried into the playa area with runoff.

2.2.1 Selection of Sample Locations

This section provides a rationale for the selection of each trenching and hand-augering area. It is a summary of the justification for sample location selection that was presented in the Work Plan (GRAM, 1994b) and the Field Sampling Plan (GRAM, 1994c) for the field sampling investigations.

2.2.1.1 Trenching

A total of 160 soil samples was collected from four separate trenching areas (40 samples per trenching area) on the McCormick Ranch site (Table 2.2, Figure 2.1, and Plate 1). The four areas selected for trenching were those considered to have the greatest likelihood of containing explosives, explosive degradation products, or other contaminants of concern in the soil based upon documented testing and the results of the geophysical surveys. The trenching areas were located in three of the five geophysical survey areas (Geophysical Survey Areas 1, 2, and 4).

Table 2.2. Summary of Trenching Information

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	DEPTH (Feet)	LOCATION DESCRIPTION*
Trenching Area 1	0001	9/14/94	0830	0-3	1A
E-W Trench	0002	9/14/94	0830	0-3	2B
(Geoph. Area 1)	0003	9/14/94	0830	0-3	3C
355E, 155N to	0004	9/14/94	0830	0-3	4D
370E, 115N	0005	9/14/94	0830	0-3	5A
	0006	9/14/94	0930	3-6	1B
	0007	9/14/94	0930	3-6	2D
	0008	9/14/94	0930	3-6	3B
	0009	9/14/94	0930	3-6	5D
	0010	9/14/94	0930	3-6	6C
	0011	9/14/94	1005	6-9	2B
	0012	9/14/94	1005	6-9	3D
	0013	9/14/94	1005	6-9	4B
	0014	9/14/94	1005	6-9	5A
	0015	9/14/94	1005	6-9	6B
	0016	9/14/94	1200	9-12	2D
	0017	9/14/94	1200	9-12	3B
	0018	9/14/94	1200	9-12	4D
	0019	9/14/94	1200	9-12	5C
	0020	9/14/94	1200	9-12	6D
Trenching Area 1	0021	9/14/94	1245	0-3	1A
N-S Trench	0022	9/14/94	1245	0-3	2B
(Geoph. Area 1)	0023	9/14/94	1245	0-3	3C
370E, 115N to	0024	9/14/94	1245	0-3	4D
370E, 130N	0025	9/14/94	1245	0-3	5A
	0026	9/14/94	1340	3-6	1B
	0027	9/14/94	1340	3-6	2C
	0028	9/14/94	1340	3-6	3D
	0029	9/14/94	1340	3-6	4A
	0030	9/14/94	1340	3-6	5B
	0031	9/14/94	1400	0-3	1C
	0032	9/14/94	1400	0-3	2D
	0033	9/14/94	1400	0-3	3B
	0034	9/14/94	1400	0-3	4A
	0035	9/14/94	1400	0-3	5C
	0036	9/14/94	1400	3-6	1C
	0037	9/14/94	1400	3-6	1A
	0038	9/14/94	1400	3-6	2D
	0039	9/14/94	1400	3-6	2A
	0040	9/14/94	1400	3-6	3C

Table 2.2. Summary of Trenching Information (continued)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	DEPTH (Feet)	LOCATION DESCRIPTION*
Trenching Area 2	0041	9/12/94	1220	0-3	1D
N-S Trench	0042	9/12/94	1220	0-3	1B
(Geoph. Area 1)	0043	9/12/94	1220	0-3	2D
70E, 270N to	0044	9/12/94	1220	0-3	5D
70E, 285N	0045	9/12/94	1220	0-3	5B
	0046	9/12/94	1310	3-6	1C
	0047	9/12/94	1310	3-6	1A
	0048	9/12/94	1310	3-6	3D
	0049	9/12/94	1310	3-6	4C
	0050	9/12/94	1310	3-6	5A
	0051	9/12/94	1345	6-9	1B
	0052	9/12/94	1345	6-9	2A
	0053	9/12/94	1345	6-9	3C
	0054	9/12/94	1345	6-9	4D
	0055	9/12/94	1345	6-9	5C
	0056	9/12/94	1420	3-6	2C
	0057	9/12/94	1420	3-6	2B
	0058	9/12/94	1420	3-6	4D
	0059	9/12/94	1420	3-6	4A
	0060	9/12/94	1420	3-6	5B
Trenching Area 2	0061	9/13/94	1100	0-3	1A
E-W Trench	0062	9/13/94	1100	0-3	2B
(Geoph. Area 1)	0063	9/13/94	1100	0-3	3C
70E, 285N to	0064	9/13/94	1100	0-3	4D
55E, 285N	0065	9/13/94	1100	0-3	5A
	0066	9/13/94	1210	3-6	1B
	0067	9/13/94	1210	3-6	2C
	0068	9/13/94	1210	3-6	3D
	0069	9/13/94	1210	3-6	4A
	0070	9/13/94	1210	3-6	5B
	0071	9/13/94	1315	6-9	1C
	0072	9/13/94	1315	6-9	2D
	0073	9/13/94	1315	6-9	3A
	0074	9/13/94	1315	6-9	4B
	0075	9/13/94	1315	6-9	5C
	0076	9/13/94	1345	3-6	1D
	0077	9/13/94	1345	3-6	2A
	0078	9/13/94	1345	3-6	3B
	0079	9/13/94	1345	3-6	4C
	0080	9/13/94	1345	3-6	5D

Table 2.2. Summary of Trenching Information (continued)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	DEPTH (Feet)	LOCATION DESCRIPTION*
Trenching Area 3 N-S Trench (Geoph. Area 2) 20E, 400N to 20E, 415N	0091	9/9/94	0815	0-3	1A
	0092	9/9/94	0815	0-3	2B
	0093	9/9/94	0815	0-3	3C
	0094	9/9/94	0815	0-3	4D
	0095	9/9/94	0815	0-3	5A
	0096	9/9/94	0900	3-6	1B
	0097	9/9/94	0900	3-6	2C
	0098	9/9/94	0900	3-6	3D
	0099	9/9/94	0900	3-6	4A
	0100	9/9/94	0900	3-6	5B
	0101	9/9/94	0945	6-9	1C
	0102	9/9/94	0945	6-9	2D
	0103	9/9/94	0945	6-9	3A
	0104	9/9/94	0945	6-9	4B
	0105	9/9/94	0945	6-9	5C
	0106	9/9/94	1030	3-6	1D
	0107	9/9/94	1030	3-6	2A
	0108	9/9/94	1030	3-6	3B
	0109	9/9/94	1030	3-6	4C
	0110	9/9/94	1030	3-6	5D
Trenching Area 3 E-W Trench (Geoph. Area 2) 20E, 415N to 5E, 415N	0111	9/12/94	0845	0-3	1A
	0112	9/12/94	0845	0-3	2B
	0113	9/12/94	0845	0-3	3C
	0114	9/12/94	0845	0-3	4D
	0115	9/12/94	0845	0-3	5A
	0116	9/12/94	0915	0-3	1C
	0117	9/12/94	0915	0-3	2D
	0118	9/12/94	0915	0-3	3A
	0119	9/12/94	0915	0-3	4B
	0120	9/12/94	0915	0-3	5C
	0121	9/12/94	1010	3-6	1B
	0122	9/12/94	1010	3-6	2C
	0123	9/12/94	1010	3-6	3D
	0124	9/12/94	1010	3-6	4A
	0125	9/12/94	1010	3-6	5B
	0126	9/12/94	1030	3-6	1D
	0127	9/12/94	1030	3-6	2A
	0128	9/12/94	1030	3-6	3B
	0129	9/12/94	1030	3-6	4C
	0130	9/12/94	1030	3-6	5D

Table 2.2. Summary of Trenching Information (concluded)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	DEPTH (Feet)	LOCATION DESCRIPTION*
Trenching Area 4 N-S Trench (Geoph. Area 4) 330E, 315N to 330E, 300N	0166	9/7/94	1300	0-3	1A
	0167	9/7/94	1300	0-3	2B
	0168	9/7/94	1300	0-3	3C
	0169	9/7/94	1300	0-3	4D
	0170	9/7/94	1300	0-3	5A
	0171	9/7/94	1400	3-6	1B
	0172	9/7/94	1400	3-6	2C
	0173	9/7/94	1400	3-6	3D
	0174	9/7/94	1400	3-6	4A
	0175	9/7/94	1400	3-6	5B
	0176	9/7/94	1500	0-3	1C
	0177	9/7/94	1500	0-3	2D
	0178	9/7/94	1500	0-3	3A
	0179	9/7/94	1500	0-3	4B
	0180	9/7/94	1500	0-3	5C
	0181	9/7/94	1530	3-6	1D
	0182	9/7/94	1530	3-6	2A
	0183	9/7/94	1530	3-6	3B
	0184	9/7/94	1530	3-6	4C
	0185	9/7/94	1530	3-6	5D
Trenching Area 4 E-W Trench (Geoph. Area 4) 330E, 300N to 315E, 300N	0186	9/8/94	0905	0-3	1C
	0187	9/8/94	0905	0-3	1A
	0188	9/8/94	0905	0-3	2D
	0189	9/8/94	0905	0-3	2B
	0190	9/8/94	0905	0-3	3C
	0191	9/8/94	0930	0-3	3A
	0192	9/8/94	0930	0-3	4D
	0193	9/8/94	0930	0-3	4B
	0194	9/8/94	0930	0-3	5C
	0195	9/8/94	0930	0-3	5A
	0196	9/8/94	1015	3-6	1D
	0197	9/8/94	1015	3-6	1B
	0198	9/8/94	1015	3-6	2C
	0199	9/8/94	1015	3-6	2A
	0200	9/8/94	1015	3-6	3D
	0201	9/8/94	1100	3-6	3B
	0202	9/8/94	1100	3-6	4C
	0203	9/8/94	1100	3-6	4A
	0204	9/8/94	1100	3-6	5D
	0205	9/8/94	1100	3-6	5B

Samples that are shaded were sent to the laboratory for analysis.

* See Figure 2.6 for trench sample locations.

Table 2.3 provides a summary of the locations and the proposed sampling activity of physical properties of each geophysical anomaly identified. Of the 160 soil samples collected during the trenching activity, 80 samples were collected from within or directly adjacent to the dry playa. The following paragraphs describe in further detail the rationale for selecting each of the trenching areas.

Trenching Area 1: This trenching area is located in Geophysical Area 1, where several of the largest tests were conducted at McCormick Ranch. Two or three HEST tests were conducted within Geophysical Area 1 during 1966 and 1967 (Table 2.1). Materials documented to have been used in the testing at or near Trenching Area 1 include: PETN, ammonium nitrate, steel, wiring, and cables. Geophysical surveys identified a large anomaly (Anomaly 1(A)) in the southeast corner of the Geophysical Area (Figure 2.2), which was the focus of the investigations at Trenching Area 1. Magnetic and EM 31 surveys located buried ferrous and non-ferrous metal in the area, and GPR transects identified possible subsurface cracks and a north-trending debris-filled trench or depression approximately 170 feet long. The trenching area is located on the northwest corner of the geophysical anomaly (Figure 2.2), and is situated on the eastern edge of a pronounced broad depression in the ground surface. In addition, the trenching area is located very close to the eastern boundary of the playa (Figure 2.1). Appendix A provides surveyed State Plane coordinates for the corners of the two trench segments in Trenching Area 1.

Trenching Area 2: This trenching area is also located in Geophysical Area 1, and was selected to investigate a HEST test. As with Trenching Area 1, materials documented to have been used in the testing at or near the trenching area include: PETN, ammonium nitrate, steel, wiring, and cables. Geophysical surveys identified a large anomaly (Anomaly 1(C)) in the northwest corner of the Geophysical Area (Figure 2.2), which was the focus of the investigations at Trenching Area 2. Magnetic and EM 31 surveys located buried ferrous and non-ferrous metal in the area, while GPR transects identified an east-trending covered trench or depression and subsurface cracks. The trenching area is located on the northeast corner of geophysical anomaly 1(C) (Figure 2.2), and is situated on the southern edge of a pronounced broad depression in the ground surface. In addition, the trenching area is located within the boundaries of the playa shown on the USGS topographic map (Figure 2.1 and USGS, 1974). Appendix A provides surveyed State Plane coordinates for the corners of the two trench segments in Trenching Area 2.

Table 2.3 Geophysical Anomalies and Proposed Sampling Activities

Geophysical Area	Anomaly	Approximate Location	Dimensions East-West	Dimensions North-South	Physical Properties	Action
1	1(A)	370E, 90N	50 FT	> 170 FT	Buried metal, including ferrous. GPR data show covered trench/depression from approximately 10-15 feet deep, buried metal, and subsurface cracks.	TRENCHING
	1(B)	210E, 220N	60 FT	50 FT	Buried ferrous materials. GPR data show small, discrete buried target approximately 2-3 feet deep.	NO ACTION
	1(C)	60E, 270N	50 FT	50 FT	Buried ferrous materials. GPR data show covered trench/depression approximately 8 feet deep, buried debris and subsurface cracks.	TRENCHING
	1(D)	160E, 275N	5 FT	20 FT	Buried non-ferrous metal. GPR data show buried debris and subsurface cracks.	HAND AUGERING
2	2(A)	20E, 410N	>60 FT	75 FT	Conductive/non-metallic anomaly. GPR data show disturbed soils.	TRENCHING
4	4(A)	280E, 370N	180 FT	130 FT	Buried non-ferrous metal - semicircle with no buried metal in center. GPR data show buried objects from near the surface to approximately 10 feet along semicircle and in the center.	TRENCHING
	4(B)	470E, 210N	>70 FT	80 FT	Buried non-ferrous metal. Field reconnaissance indicated anomaly is related to a buried cable run.	NO ACTION
5	5(A)	190E, 250N	220 FT	80 FT	Buried metal, including ferrous - anomaly larger than explained by surface features. GPR data show small, discrete buried objects from the surface to approximately 8 feet deep.	HAND AUGERING
	5(B)	170E, 350N	200 FT	50 FT	Buried ferrous materials - six small north-south trending anomalies approximately 30 ft. apart. GPR data show small, discrete buried objects at a depth of approximately 1-2 feet.	HAND AUGERING
	5(C)	40E, 450N	40 FT	45 FT	Buried metal, including ferrous. GPR data show buried objects from approximately 3-4 feet.	HAND AUGERING
	5(D)	210E, 460N	60 FT	60 FT	Metal, including ferrous. GPR data did not show buried target.	NO ACTION
	5(E)	180E, 40N	30 FT	30 FT	Ferrous materials. Field reconnaissance identified metal object (geophone) on surface.	NO ACTION
	5(F)	220E, 90N	30 FT	30 FT	Buried metal, including ferrous. GPR data show small, discrete buried objects from near the surface to approximately 2 feet.	NO ACTION
GRAVEL PIT	G(1)	NA	>75 FT	Approximately 75 FT	Buried metal. GPR data show buried debris.	HAND AUGERING

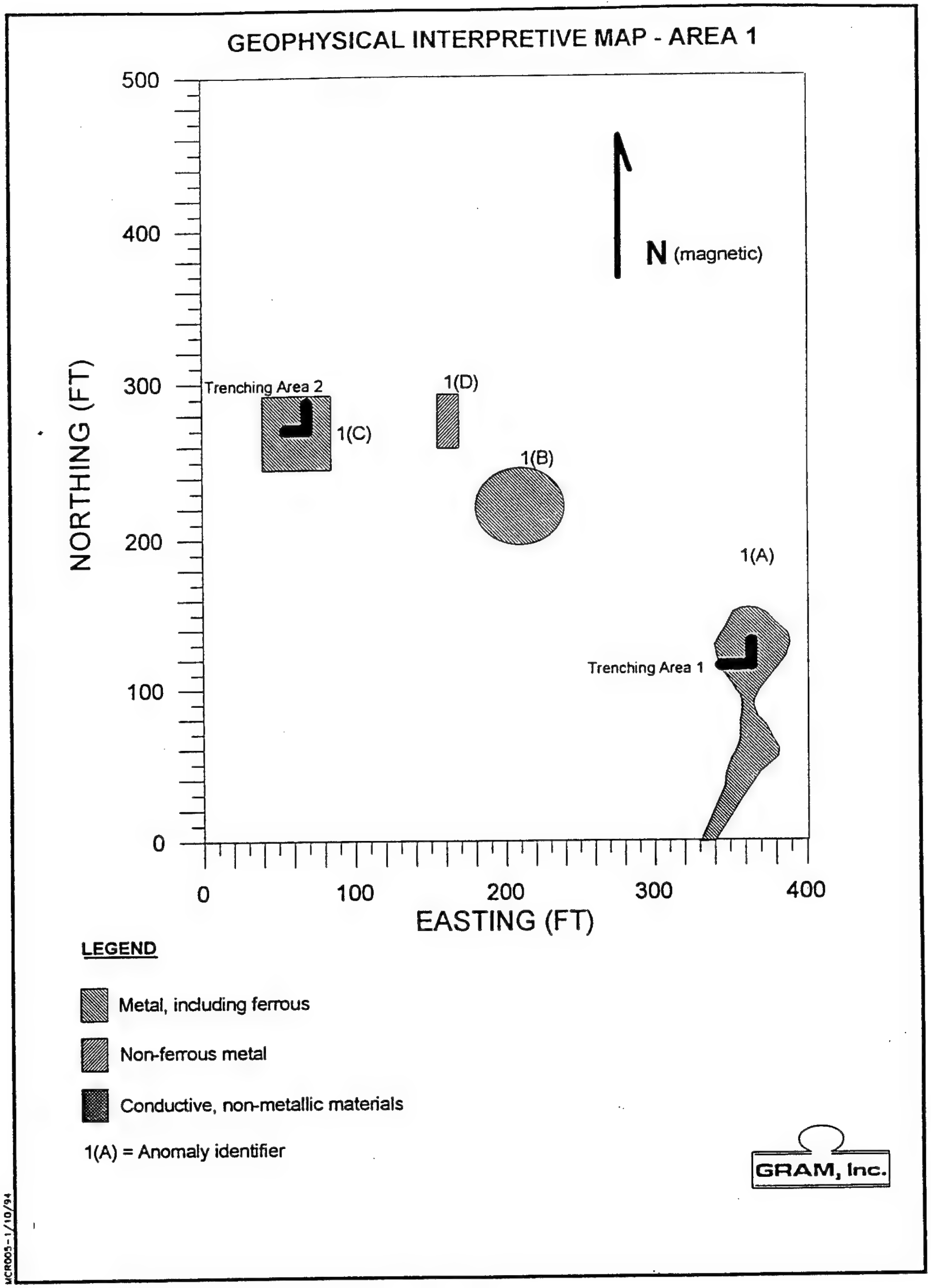

Figure 2.2 Interpretive Map of Geophysical Area 1

Trenching Area 3: This trenching area is located in Geophysical Area 2, where at least five known tests, and possibly numerous additional tests, were conducted in the 1980s and 1990s. Combinations of surface and subsurface tests are known to have been conducted within Geophysical Area 2 (Table 2.1). Materials documented to have been used in testing in the vicinity of Trenching Area 3 include: RDX, motor oil, propylene oxide, PETN, TNT, aluminum, sodium/potassium nitrate, ammonium nitrate and fuel oil (ANFO), steel, wiring, and cables. Geophysical methods identified a subsurface anomaly (Anomaly 2(A)) in the northwest corner of Geophysical Area 2 (Figure 2.3), which was the focus of investigations at Trenching Area 3. Magnetic and EM 31 surveys identified a conductive non-metallic anomaly in the area, interpreted to be related to conductive soils. A pronounced depression in the ground surface is present, along with buried cables running from the anomalous area (indicating a potential HE test site). The trenching area is located in the center of the geophysical anomaly (Figure 2.3). Appendix A provides surveyed State Plane coordinates for the corners of the two trench segments in Trenching Area 3.

Trenching Area 4: This trenching area is located in Geophysical Area 4, where the Mini Sim Quake, Conventional High Explosive Blast Simulation (CHEBS, approximately 10 separate tests), and Bomb Tests (at least 6 separate tests) are known to have been conducted on the surface and in the subsurface between 1977 and 1992 (Table 2.1). The trenching area is located in the vicinity of the CHEBS and Bomb tests, where test materials included: RDX, motor oil, PETN, TNT, aluminum, steel, wiring, and cables. Geophysical methods identified a large (180 feet wide), semicircular anomaly related to buried, non-ferrous metal (Anomaly 4(A)) in the center of Geophysical Area 4, with buried debris inside of the semicircle (Figure 2.4). Trenching Area 4 focused on investigating debris within the southeast portion of the semicircular anomaly, where GPR transects identified what appeared to be an east-west trending subsurface trench. Appendix A provides surveyed State Plane coordinates for the corners of the two trench segments in Trenching Area 4.

2.2.1.2 Hand Augering

In addition to samples collected from the four trenching areas, a total of 152 soil samples were collected by hand-augering from 13 separate HE testing areas or debris disposal areas on the McCormick Ranch site, and from two off-site locations west of McCormick Ranch (Table 2.4, Figure 2.1, Plate 1). While the hand-augering activity primarily investigated smaller surface and near-surface HE tests than those investigated during the trenching activity, the number of hand-

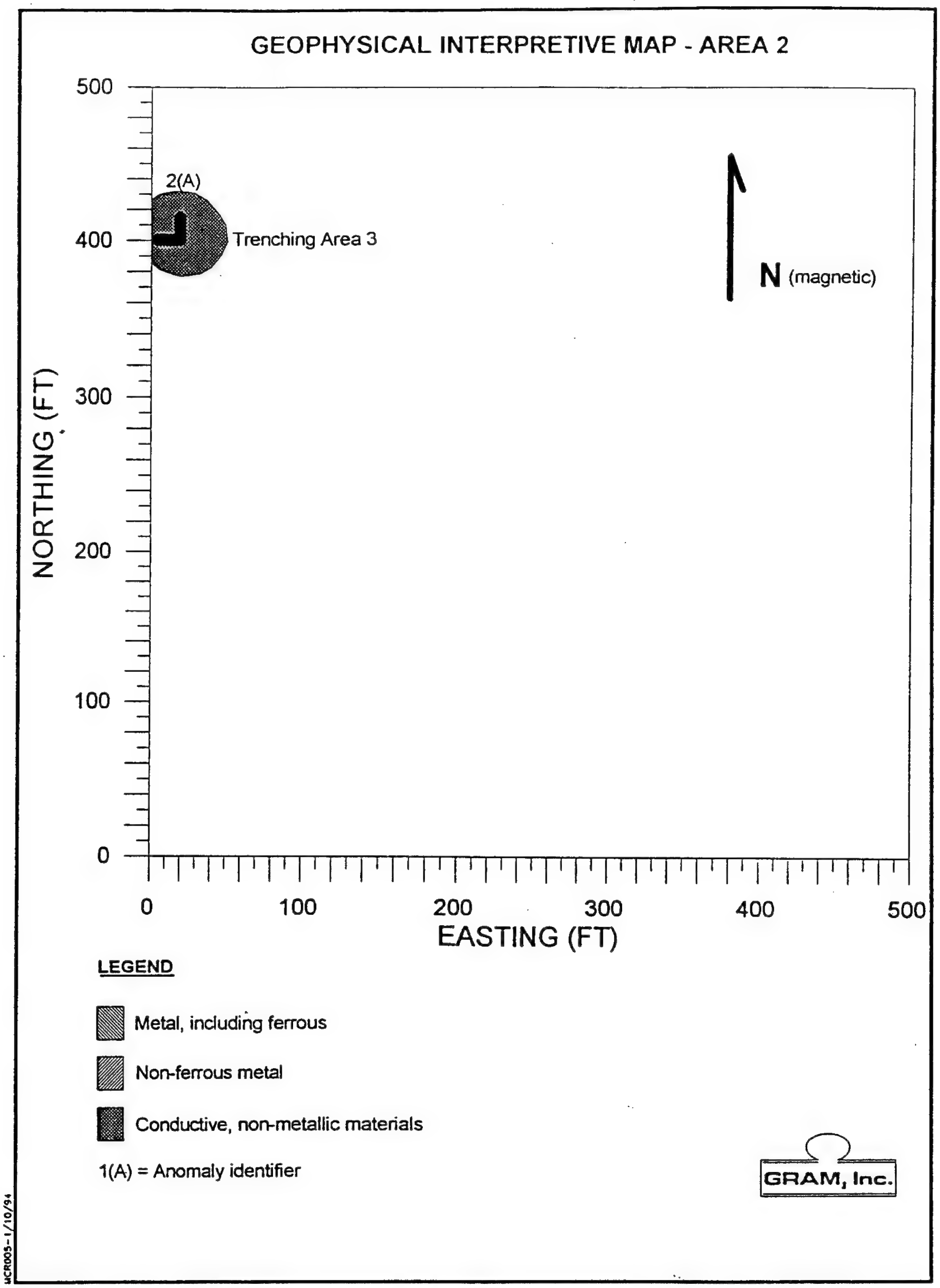

Figure 2.3 Interpretive Map of Geophysical Area 2

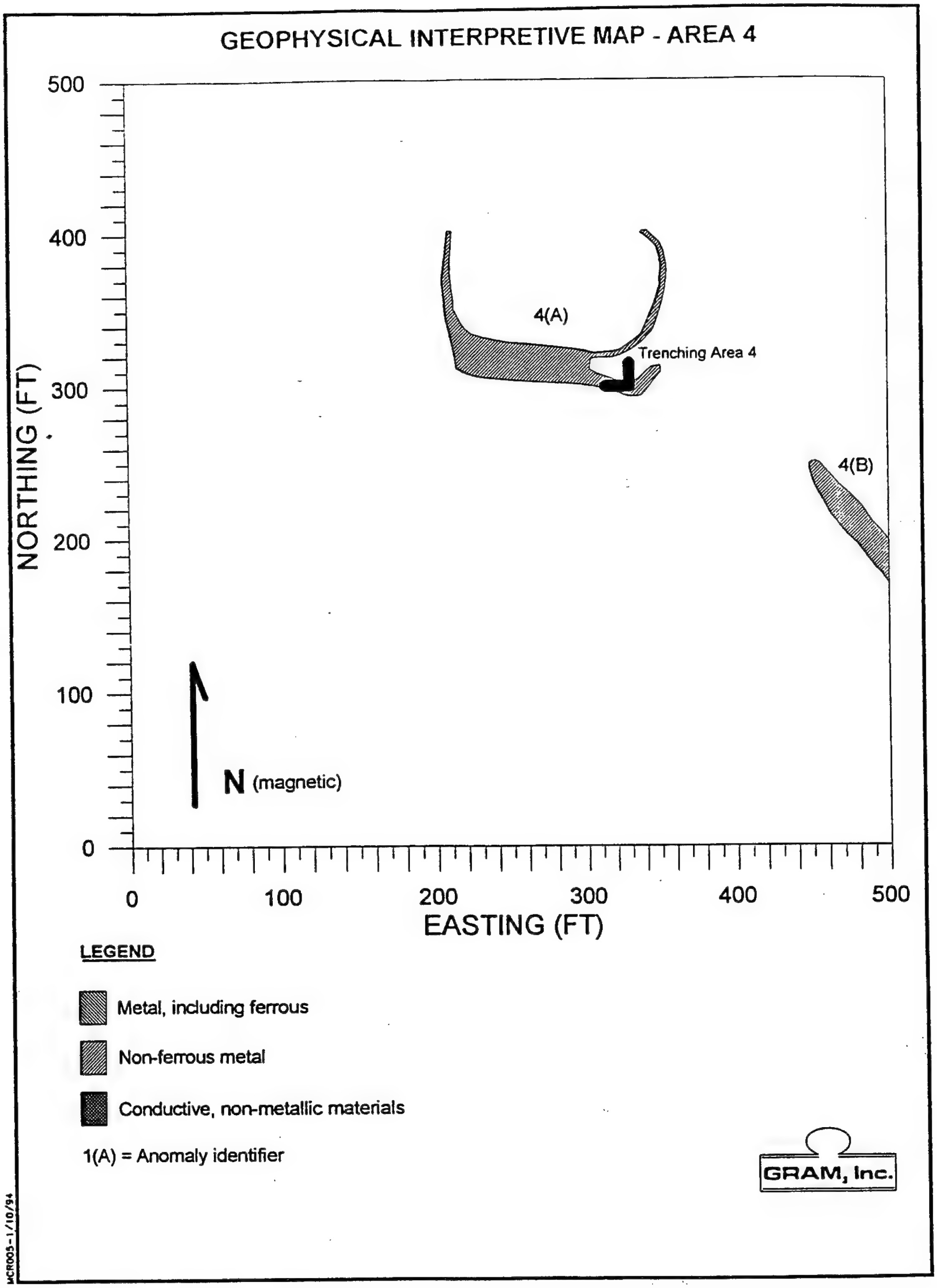

Figure 2.4 Interpretive Map of Geophysical Area 4

Table 2.4 Summary of Hand Augering Information

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	GENERAL LOCATION DESCRIPTION *
Geophysical Area 1	0081	8/25/94	1030	In depression near trenching area 2. About 100' west of road.
	0082	8/25/94	1030	In depression near trenching area 2. About 100' west of road.
	0083	8/25/94	1200	Near trenching area 2. Approx. 40' west of road. Grid 140E, 180N. HEST Test
	0084	8/25/94	1207	Near trenching area 2. Approx. 40' west of road. Grid 140E, 180N. HEST Test
	0085	8/25/94	1356	Near geophysical anomaly at grid 220N, 210E.
	0086	8/25/94	1350	Near 220N, 21E of geophysical area 1. Just east of road.
	0087	8/25/94	1452	In depression near trenching area 1. HEST Test
	0088	8/25/94	1445	In depression near trenching area 1. HEST Test
	0089	8/25/94	1549	Grid 380E, 0N. HEST Test
	0090	8/25/94	1550	Grid 360E, 40N. HEST Test
Geophysical Area 2	0131	9/15/94	0950	Crater at grid 0E, 230N. North side of crater.
	0132	9/15/94	0949	Inside crater wall at grid 0E, 210N.
	0133	9/15/94	1010	Near bunker on south side. Grid 240N, 120E. Modular Storage Magazine Test
	0134	9/15/94	1015	Near bunker on northeast side. Grid 260N, 160E. Modular Storage Magazine Test
	0135	9/15/94	1055	West side of crater, inside crater rim, grid 190N, 380E.
	0136	9/15/94	1051	North side of crater, on rim of crater, grid 210N, 390E.
	0137	9/15/94	1110	East side of crater, grid 190N, 410E.
	0138	9/15/94	1110	South side of crater, on rim of crater, grid 170N, 400E.
	0139	9/15/94	1200	Approx. 50' east of NE corner of grid. SW side of large depression.
	0140	9/15/94	1201	Approx. 50' east of NE corner of grid. South side of large depression.
	0141	9/15/94	1225	Approx. 50' east of NE corner of grid. NE side of large depression.
	0142	9/15/94	1222	Approx. 50' east of NE corner of grid. NE corner of depression.
	0143	9/16/94	0840	Desert fire casings at grid 0N, 40E. Westernmost of 2 adjacent sampling locations. Desert Fire Test
	0144	9/16/94	0840	Desert fire casings at grid 0N, 40E. Easternmost of 2 adjacent sampling locations. Desert Fire Test
	0145	9/16/94	0900	Approx. 100' SW of grid. In large trench. Next to well casing. Southernmost of 2 adjacent samples. Desert Fire Test
	0146	9/16/94	0900	Approx. 100' SW of grid. In large trench. Next to well casing. Northernmost of 2 adjacent sampling locations. Desert Fire Test

Table 2.4 Summary of Hand Augering Information (continued)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	GENERAL LOCATION DESCRIPTION *
Geophysical Area 2 (continued)	0147	9/16/94	0940	Small crater approx. 50' west of 0145 and 0146. Well casing in crater is collaped in on itself. Desert Fire Test
	0148	9/16/94	0940	Small crater approx. 50' west of 0145 and 0146. Well casing in crater is collaped in on itself. Desert Fire Test
	0149	9/16/94	1005	Crater approx. 150' south of SW corner of grid.
	0150	9/16/94	1005	Crater approx. 150' south of SW corner of grid.
Geophysical Area 3	0151	8/26/94	0900	Crater in SW corner. North side of crater, just outside crater. Grid 80N, 160E. SSTM Test
	0152	8/26/94	0903	Crater in SW corner. Grid 50N, 200E. SSTM Test
	0153	8/26/94	0930	Crater in SW corner. East side of crater. Grid 40N, 170E. SSTM Test
	0154	8/26/94	0933	Crater in SW corner. Inside crater. Grid 50N, 150E. SSTM Test
	0155	8/26/94	1035	Grid 260N, 240E. On south side of crater edge. SSTM Test
	0156	8/26/94	1040	Grid 260N, 260E. SSTM Test
	0157	8/26/94	1100	Grid 280N, 240E. North side of crater, inside rim of crater. SSTM Test
	0158	8/26/94	1103	Grid 200N, 260E. SSTM Test
	0159	8/26/94	1210	Grid 300N, 240E. South side of crater on rim. SSTM Test
	0160	8/26/94	1213	Grid 320N, 340E. SSTM Test
	0161	8/26/94	1235	Grid 300N, 220E. West side of crater. SSTM Test
	0162	8/26/94	1238	Grid 320N, 225E. On outer edge of crater. SSTM Test
	0163	8/26/94	1320	Grid 320N, 520E. Edge of crater. SSTM Test
	0164	8/26/94	1320	Grid 340N, 500E. In center of crater. SSTM Test
	0165	8/26/94	1340	Grid 360N, 500E. North edge of crater. SSTM Test
Geophysical Area 4	0206	9/16/94	1040	150' west of NW corner of grid. In linear depression on north side. 30' south of road. Mini Sim Quake Test
	0207	9/16/94	1040	150' west of NW corner of grid. In linear depression. Mini Sim Quake Test
	0208	9/16/94	1100	150' west of NW corner of grid. In center of linear depression. Mini Sim Quake Test
	0209	9/16/94	1100	150' west of NW corner of grid. At southern end of linear depression. Mini Sim Quake Test
	0210	9/16/94	1135	40' west of NW corner of grid. In n-s depression. Northernmost sample in depression. Mini Sim Quake Test
	0211	9/16/94	1135	Grid 0E, 500N. In n-s depression. Mini Sim Quake Test
	0212	9/16/94	1200	Grid 10E, 480N. In n-s depression. Mini Sim Quake Test
	0213	9/16/94	1200	Grid 10E, 470N. In n-s depression. Mini Sim Quake Test
	0214	9/19/94	0815	Grid 230E, 300N. On northern edge of borrow area.

Table 2.4 Summary of Hand Augering Information (continued)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	GENERAL LOCATION DESCRIPTION *
Geophysical Area 4 (continued)	0215	9/19/94	0815	Grid 240E, 300N. Borrow area.
	0216	9/19/94	0830	Grid 260E, 300N. Approx. 20' west of borrow area.
	0217	9/19/94	0830	Grid 280E, 300N.
	0218	9/19/94	0905	Grid 350N, 290E. On top of small debris pile.
	0219	9/19/94	0905	Grid 260E, 360N.
	0220	9/19/94	0930	Grid 300E, 360N. On east side of dirt pile and excavation.
	0221	9/19/94	0930	Grid 290E, 370N.
	0222	9/19/94	1005	Approx. 200 NE of NE corner of grid. 100' south of road. In depression on south side.
	0223	9/19/94	1005	Approx. 200 NE of NE corner of grid. 100' south of road. In depression.
	0224	9/19/94	1030	Approx. 200 NE of NE corner of grid. 100' south of road. In depression on west side.
	0225	9/19/94	1030	Approx. 200 NE of NE corner of grid. 100' south of road. In depression.
	0226	8/30/94	1117	Just east of I-beam. Grid 240N, 200E. Southernmost of 2 adjacent samples.
Geophysical Area 5	0227	8/30/94	1118	Just east of I-beam. Grid 240N, 200E. Northernmost of 2 adjacent samples. DABS Test
	0228	8/30/94	1145	Grid 350N, 170E. Northernmost of 2 adjacent samples. DABS Test
	0229	8/30/94	1143	Grid 350N, 170E. Southernmost of 2 adjacent samples. DABS Test
	0230	8/30/94	1257	Grid 460N, 80E. Adjacent to green post. DABS Test
	0231	8/30/94	1254	Grid 450N, 40E. DABS Test
	0232	8/30/94	1315	North of area 5 by approx 150'. Approx. 100' north of large crater. Adjacent to green post. DABS Test
	0233	8/30/94	1321	North of area 5 by approx 150'. Approx. 100' north of large crater. 5' east of green post. DABS Test
	0234	8/30/94	1410	North of area 5 by approx 50'. Inside south rim of large crater on SW side.
	0235	8/30/94	1411	North of area 5 by approx 50'. On western slope of large crater.
	0236	8/30/94	1438	North of area 5 by approx 50'. On south rim of crater.
	0237	8/30/94	1438	North of area 5 by approx 50'. On NE side of crater.
	0238	8/31/94	0845	Approx. 200' north of grid. 75' north of green post (0232, 0233). In area of exposed concrete. DABS Test
	0239	8/31/94	0845	Approx. 200' north of grid. 75' north of green post (0232, 0233). In area of exposed concrete. DABS Test
	0240	8/31/94	0910	Approx. 75' north of 0238, 0239. DABS Test
	0241	8/31/94	0910	Approx. 75' north of 0238, 0239. DABS Test

Table 2.4 Summary of Hand Augering Information (continued)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	GENERAL LOCATION DESCRIPTION *
Geophysical Area 5 (continued)	0242	8/31/94	1005	Approx. 250' east of 0240, 0241. Near concrete pad covered with steel plate. Sample from SW side of pad. DABS Test
	0243	8/31/94	1006	Approx. 250' east of 0240, 0241. Near concrete pad covered with steel plate. DABS Test
	0244	8/31/94	1035	Dabs test II-B (pipe visible). Northernmost of all samples in area. About 200' east of desert fire casings on road. DABS Test
	0245	8/31/94	1039	Dabs test II-B (pipe visible). Northernmost of all samples in area. About 200' east of desert fire casings on road. DABS Test
Gravel Pit	0246	9/2/94	0827	50' east of road. On west side of pit. Southernmost location.
	0247	9/2/94	0825	West side of pit. 50' east of road. Furthest location west. In washout area.
	0248	9/2/94	0845	75' east of road. Northernmost sample area. Outside pit area.
	0249	9/2/94	0910	In pit about 20' from edge. Approx. 100' east of road.
	0250	9/2/94	0909	100' east of road. In entrance to gravel pit. Easternmost location.
DIP 5	0251	9/1/94	0908	West side of road. Far western depression approx. 75' from road. North side of depression.
	0252	9/1/94	0909	West side of road. Far western depression approx. 75' from road. South side of depression.
	0253	9/1/94	0933	West side of road. Approx. 50' from road centered between depressions.
	0254	9/1/94	0930	15' west of road. In depression on south side.
	0255	9/1/94	1022	15' west of road. In center of depression.
	0256	9/1/94	1016	15' west of road. In north side of depression.
	0257	9/1/94	1043	First depression east of road. On south side of depression.
	0258	9/1/94	1035	Depression 10' east of road. On north side of depression. Found aluminum shavings.
	0259	9/1/94	1148	Approx. 50' east of road. 20' east of depression closest to road.
	0260	9/1/94	1145	Approx. 75' east of road. Flat area east of depression closest to road.
	0261	9/1/94	1212	2nd depression east of road. 100' east of road. On south side of depression.
	0262	9/1/94	1210	2nd depression east of road. 100' east of road. On north side of depression.
	0263	9/1/94	1300	Flat area approx 125' east of road. Centered between 2nd and 3rd depressions.
	0264	9/1/94	1300	Far eastern depression. North side of depression. 200' east of road.
	0265	9/1/94	1316	Far eastern depression. South side of depression. 200' east of road.
Generator Site	0266	9/2/94	0957	10' east of loop road.
	0266	9/9/94	1123	10' east of loop road.
	0267	9/2/94	0950	Between large concrete blocks.
	0268	9/2/94	1010	On high area. Farthest from steel retaining wall.
	0269	9/2/94	1030	Next to steel retaining wall. On north side.
	0270	9/2/94	1029	Next to steel retaining wall. On south side.

Table 2.4 Summary of Hand Augering Information (continued)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	GENERAL LOCATION DESCRIPTION *
Fuselage	0271	8/30/94	0939	NE corner of fuselage.
	0272	8/30/94	0933	South end of fuselage.
	0273	8/30/94	1004	100' north of fuselage. Southeasternmost sample in group of 3.
	0274	8/30/94	1015	100' north of fuselage. Westernmost sample in group of 3.
	0275	8/30/94	1025	100' north of fuselage. Northernmost sample in group of 3.
Art Test	0276	8/24/94	0915	Test bed pad. Northeasternmost pad. Next to mound.
	0277	8/24/94	0915	Test bed pad. Southeasternmost pad. From center of crater.
	0278	8/24/94	1145	Pad farthest to the NW. Just west of 0276.
	0279	8/24/94	1142	Southwesternmost pad. From center of debris on pad.
	0280	8/24/94	1255	Debris pile 50' west of location 0278.
	0281	8/24/94	1305	Large dirt mound north of westernmost pad.
	0282	8/24/94	1405	25' north of 0278 (northwesternmost pad).
	0283	8/24/94	1404	Small dirt mound northeast of SE pad.
	0284	8/25/94	0820	15' north of southeasternmost pad.
	0285	8/25/94	0828	33' east of NE corner of southeasternmost pad.
Hi Fi Test Bed A	0286	8/31/94	1130	Easternmost crater. On west side of crater.
	0287	8/31/94	1133	Easternmost crater. NE corner of crater.
	0288	8/31/94	1200	Easternmost crater. SW corner of crater.
	0289	8/31/94	1155	Middle crater. On east side of crater.
	0290	8/31/94	1304	Middle crater. On western edge of crater.
	0291	8/31/94	1305	Middle crater. On south side of crater rim.
	0292	8/31/94	1325	Westernmost crater. On western edge of crater.
	0293	8/31/94	1325	Westernmost crater. On east rim of crater.
	0294	8/31/94	1405	Westernmost crater. On northern edge of crater.
	0295	8/31/94	1405	Crater/debris pile 25' north of westernmost test bed.
DCT Hest	0296	9/2/94	1120	Near 1st small dirt pile approx. 150' west of road.
	0296	9/9/94	1138	Near 1st small dirt pile approx. 150' west of road.
	0297	9/2/94	1117	Approx. 200' west of road. Next to dirt mound.
	0298	9/2/94	1138	Southwest of 2nd dirt pile from road. S/SE of decon bunker.

Table 2.4 Summary of Hand Augering Information (concluded)

SAMPLING AREA	LOCATION ID NUMBER	DATE SAMPLED	TIME SAMPLED	GENERAL LOCATION DESCRIPTION *
	0299	9/2/94	1158	Continued southwest of 2nd dirt pile. South of decon bunker.
	0300	9/2/94	1200	Far west sample in open area. Probably 700' from fence line. 100' south of large dirt pile.
SSTM Add-On	0301	8/29/94	0851	Crater approx. 100' SW of Area 3. Southern edge of crater. 50' north of road.
	0302	8/29/94	0845	Crater approx. 100' SW of Area 3. NE edge of crater. 50' north of road.
	0303	8/29/94	0915	Approx. 75' south of road. 100' E/NE of large pipe. On north edge of crater.
	0304	8/29/94	0915	Approx. 75' south of road. South edge of crater.
	0305	8/29/94	1002	South side of crater approx. 200' NW of USGS well 1001. 100' south of road to area 3.
	0306	8/29/94	1000	North side of crater approx. 200' NW of USGS well 1001. 100' south of road to area 3.
	0307	8/29/94	1027	Approx. 150' north of USGS well 1001. On east edge of crater.
	0308	8/29/94	1025	Approx. 150' north of USGS well 1001. On west edge of crater.
	0309	8/29/94	1109	Approx. 150' NE of USGS well 1001. Approx. 75' east of 0307, 0308. SW edge of crater.
	0310	8/29/94	1105	Approx. 150' NE of USGS well 1001. Approx. 75' east of 0307, 0308. North edge of crater.
Background	0311	10/12/94	0945	Approx. 1/2 mile west of mile marker 6 along fence road. On southern border of ranch.
	0312	10/12/94	1010	Approx. 1/4 mile west of monitoring well 1004.

* Sampling locations were accurately surveyed to +/- 0.01 ft in state-plane coordinates and are shown on Plate 1 by Location ID Number.
Samples that are shaded were sent for laboratory analysis.

auger sample locations investigated provided more thorough coverage of the McCormick Ranch site. The HE testing or debris disposal areas investigated with hand-auger sampling included: Geophysical Areas 1-5, Gravel Pit, Dip 5 Test, Generator Site, Fuselage, Art Tests, Hi Fi Test Bed A, DCT HEST, and SSTM Add-On. Hand-auger sampling investigated surface tests, shallow subsurface tests, potential hazardous material release sites, and debris disposal sites. Hand-augering sample locations were selected in the field based on readily visible surface features, NMERI maps, site reconnaissance with persons formerly involved in testing at the site, and/or results of the geophysical surveys. Hand-augering locations were also selected so that the dry playa would be adequately investigated. Of the 152 hand-auger sample locations, 65 samples (43%) were within or directly adjacent to the boundaries of the playa shown on the USGS topographic map (Figure 2.1 and USGS, 1974). Appendix A provides surveyed State Plane coordinates for each hand-auger sampling location. The following discussion describes the rationale for selecting each of the 13 hand-auger sampling areas, and the two off-site sampling locations.

Geophysical Area 1: Although two trenching areas are located in Geophysical Area 1, ten additional hand-auger soil samples were collected to provide additional coverage of the area where several of the largest tests (HEST tests) at McCormick Ranch were conducted. Test materials known to have been used at the site include: PETN, ammonium nitrate, steel, wiring, and cables. Geophysical investigations identified ferrous and non-ferrous metal subsurface geophysical anomalies at several locations other than those selected for trenches (Table 2.1 and Figure 2.2). Additional samples were collected around the large surface depressions so that the HEST test locations would be thoroughly investigated. The hand-auger sampling locations in this area are located within or directly adjacent to the boundaries of the playa shown on the USGS topographic map (Figure 2.1 and USGS, 1974).

Geophysical Area 2: While one trenching area is located in Geophysical Area 2, the trenching area investigated only one specific test in a 500 feet x 500 feet area where the ground surface is extensively disturbed. An additional 20 hand-auger soil samples were collected to investigate the Desert Fire test sequence in the southwest corner of the area, the Modular Storage Magazine test in the northwest corner of the area, bomb craters on the east side of the area, and a large surface depression approximately 100 feet northeast of the area. Test materials known to have been used in the area include: RDX, motor oil, propylene oxide, PETN, TNT, aluminum, sodium/potassium nitrate, ANFO, steel, wiring, and cables.

Geophysical Area 3: Geophysical surveys did not identify any anomalies in Geophysical Area 3 that indicate the presence of buried test debris. However, at least four large craters from the Standard Silo Test Mechanism (SSTM) and Berm Loaded Explosives Simulation Technique (BLEST) tests are still visible in the area, and several capped two-inch diameter metal casings used to house geophones are present immediately outside of the boundaries of the area (Don Bruckner, personal communication, 1994). A total of 15 hand-auger soil samples were collected to investigate soils in and around the large craters. Test materials known to have been used include: PETN, ANFO, sodium nitrate, ammonium nitrate, fuel oil, aluminum, steel, wiring, and cables.

Geophysical Area 4: Geophysical surveys located large quantities of test debris (buried metal and cables) in Geophysical Area 4, possibly related to the Bomb, CHEBS, and Mini Sim Quake tests. Site reconnaissance also located visible evidence of several trenches, mounds, and craters with associated test debris (cement, metal, and cables) in and around the borders of the gridded area. Although one trenching area is located in the central portion of Geophysical Area 4, 20 additional hand-auger soil samples were collected to more thoroughly evaluate the soils within this area. Test materials known to have been used in the area include: RDX, motor oil, PETN, TNT, aluminum, steel, wiring, and cables. Two linear depressions at the northwest corner of the area, possibly associated with the Mini Sim Quake test (the largest test conducted at McCormick Ranch), were investigated. Soil samples were also collected to the northwest of Trenching Area 4 in an area where buried debris was identified during the geophysical surveys (Table 2.1 and Figure 2.3). Additional soil samples were collected in the surface depression northeast of the area because it was reported to be a small precursor test to the Mini Sim Quake test.

Geophysical Area 5: While no trenching areas were selected in Geophysical Area 5, geophysical surveys located numerous small ferrous metal geophysical anomalies that were investigated by hand-auger sampling (Table 2.1, Figure 2.5). Geophysical Area 5 is located in the area of the Dynamic Air Blast Simulation (DABS) test sequence (approximately 25 tests), conducted on the surface and in the near subsurface during the 1970s and 1980s. Many of the DABS tests are marked by two-inch diameter metal pipes with test numbers inscribed on the pipe caps. A total of 20 hand-auger soil samples were collected to investigate three geophysical anomalies in the northwest corner of the area, a large crater approximately 50 feet north of the area, and five DABS tests up to 500 feet north of the gridded area. Test materials known to have been used in the tests include: PETN, RDX, ANFO, sodium nitrate, ammonium nitrate, fuel oil, aluminum, steel, wiring, and cables. The hand-auger sampling locations in this area are located within the boundaries of the playa shown on the USGS topographic map (Figure 2.1 and USGS, 1974).

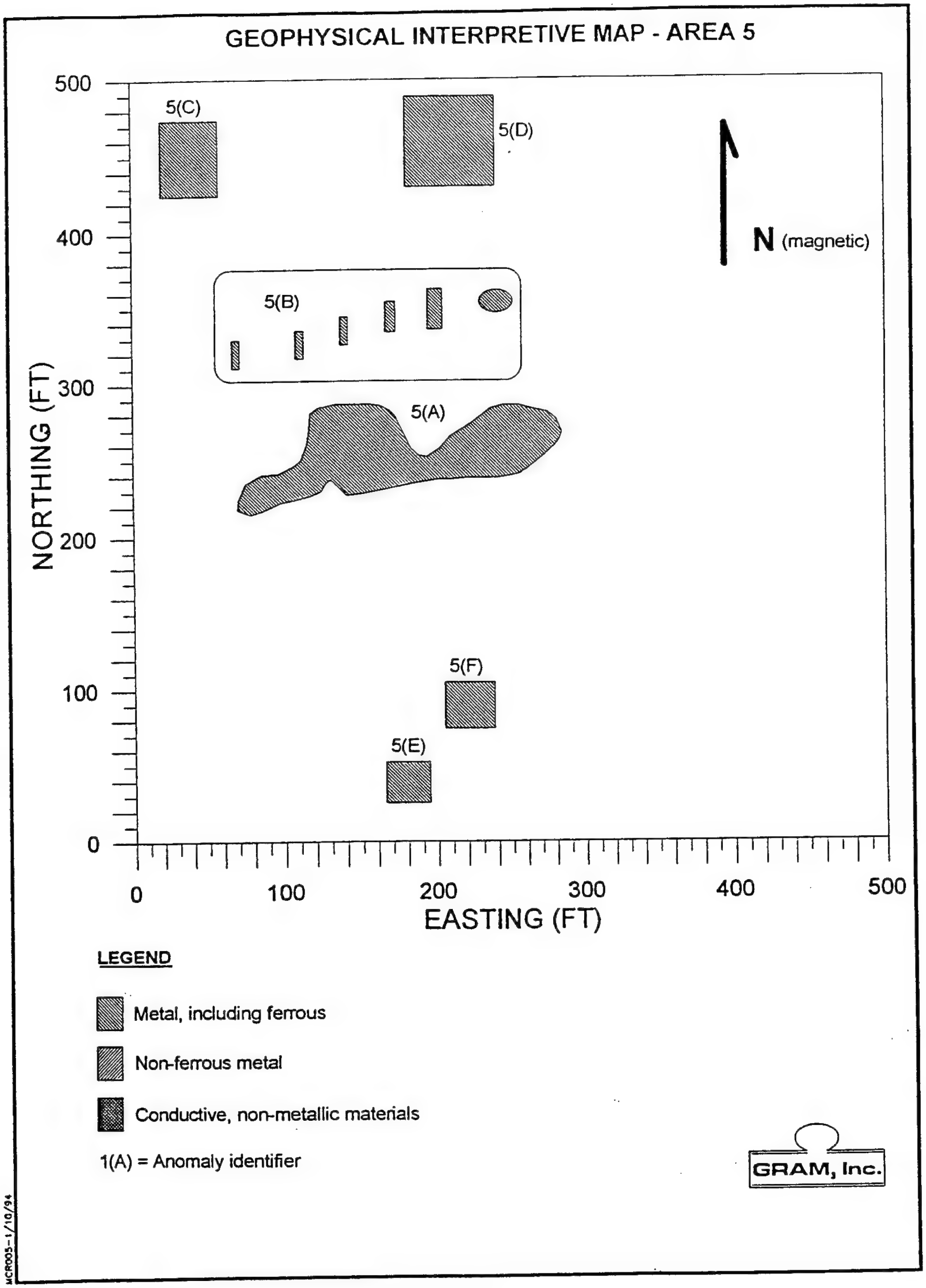

Figure 2.5 Interpretive Map of Geophysical Area 5

Gravel Pit: Geophysical surveys and visual inspection of the gravel pit identified buried debris on the southwest side of the pit. The debris was identified as buried and visible metal, and may include some buried concrete, and wood. Visual inspection during the preliminary field investigations showed no indication of the disposal of any materials other than test debris in the gravel pit. A total of five hand-auger soil samples were collected to identify any contaminants in the soil related to debris burial. The hand-auger sampling locations in this area are located within the boundaries of the playa shown on the USGS topographic map (Figure 2.1 and USGS, 1974).

DIP 5 Test: The DIP 5 test, conducted in 1973, initially involved the placement of gelled explosives (Ireco No. DBA-22M) into 16 boreholes, each approximately 300 feet deep. However, because of difficulties in pumping the explosives into the boreholes, 15,000 pounds of the explosives were flushed out of the boreholes onto the ground surface. A new mixture of less viscous (Ireco No. 65T2) explosives was then added to each borehole, and the explosives were subsequently detonated. Test materials known to have been detonated or flushed onto the ground surface include: TNT, ammonium nitrate, sodium nitrate, fuel oil, and aluminum. The locations of the boreholes could be identified by depressions resulting from trenching activities that were conducted after the test to check for complete detonation at each borehole. A total of 15 hand-auger soil samples were collected within topographic lows in the area where flushed explosives may have been concentrated. The hand-auger sampling locations in the DIP 5 Test area are located within the boundaries of the playa shown on the USGS topographic map (Figure 2.2 and USGS, 1974).

Generator Site: The generator site tests, conducted in 1985, involved the detonation of numerous small explosive shots (<100 pounds each) on the surface. Test materials known to have been used include: TNT, PETN, fuels, and large quantities of copper. A total of five hand-auger soil samples were collected to evaluate residual contamination in the test bed from the explosives and metals.

Fuselage Site: Firefighting training was conducted at the fuselage site, and involved setting the fuselage on fire with fuel oils and extinguishing the fire with various compounds of unknown, composition (except for halon). The training took place at the existing site of the fuselage, and at a location approximately 100 feet north of the existing site. A total of five hand-auger soil samples were collected to determine if fuels and fire retardant materials used in the area introduced contaminants into the soil. The hand-auger sampling locations in this area are within or directly adjacent to the boundaries of the playa (Figure 2.1 and USGS, 1974).

Art Tests: The Art Tests were a number of small surface tests (ten pounds each) conducted between 1982 and 1992. Test materials known to have been used include: PETN, TNT, and RDX. Five of the test beds are still intact, and test debris (plaster and metal fragments) is scattered in and around the test beds. A total of ten hand-auger soil samples were collected to determine if any contaminants from the test materials are present on the concrete pads, soils around the concrete pads, and areas within the blast radius of the tests.

Hi Fi Test Bed A: Surface tests were conducted at the Hi Fi Test Bed A in 1984 using small quantities of PETN, ammonium nitrate, sodium nitrate, fuel oil, and aluminum. Three concrete test beds are still intact, although they are partially buried. A small debris pile containing metal, wiring, and concrete is also present to the northwest of the test beds. A total of ten hand-auger soil samples were collected to investigate the three test beds and the debris pile. The hand-auger sampling locations in this area are located within or directly adjacent to the boundaries of the playa (Figure 2.1 and USGS, 1974).

DCT HEST: The DCT HEST test series (at least 20 surface tests), which were conducted from 1980 to 1982, involved the detonation of large quantities of explosives (approximately 3,080 lbs/test). Test materials known to have been used in the area include: PETN, ammonium nitrate, sodium nitrate, aluminum, and fuel oil. While detailed information on the tests is limited, the size of the tests warranted collection of some hand-auger soil samples. Visible remains of the test sites are minimal, but five hand-auger soil samples were collected from areas of obvious ground disturbance.

SSTM Add-On: Additional SSTM tests were conducted to the south and southwest of Geophysical Area 3. Test materials known to have been used in the area include: PETN, ANFO, fuel oil, ammonium nitrate, aluminum, sodium nitrate, steel, wiring, and cables. A total of ten hand-auger soil samples were collected to investigate in and around four large craters that probably resulted from the SSTM tests.

Off-Site Locations: Off-site soil samples were collected from remote areas where no explosives testing is known to have occurred. The two off-site locations were selected to provide soils that were not influenced by the HE tests, but that are from depositional settings similar to on-site soils. One off-site sample was collected along the south fence line adjacent to the Isleta Indian Reservation approximately one mile west of the western-most HE testing locations at McCormick Ranch (Hi Fi Test Bed A). The second off-site soil sample was collected northwest of the McCormick Ranch site approximately ¼ mile west of monitoring well KAFB 1004. The

two off-site soil samples were not intended to establish "background" conditions for statistical purposes, but were collected to determine if metals or nitrate concentrations exceed Soil Action Levels (SALs) in the absence of explosive testing.

2.2.2 Sampling Methods

This section provides a description of the field-sampling methods used for the trenching and hand-augering activities. It summarizes the detailed sampling methods and procedures that were presented in the Field Sampling Plan (GRAM, 1994c) and Standard Operating Procedures (GRAM, 1994e), and that were followed during the sampling activities.

2.2.2.1 Trenching

A total of 160 soil samples were collected from four trenching areas. This section describes the excavation procedures and sampling methods used during the trenching activity.

The site supervising geologist was responsible for the confirmation of native undisturbed soils. Native undisturbed soils were identified by the presence of an approximately 5-foot thick calcium carbonate-cemented (caliche) horizon, which is a common soil horizon that forms in the arid climate of the southwest United States. Rainfall runoff that percolates into the soil horizon dissolves calcium carbonate held in the soils near the ground surface and, as the percolating water evaporates or is transpired through plant roots, calcium carbonate is redeposited in a rich layer usually several feet below the ground surface. The process of developing a thick caliche layer takes thousands of years, so the presence of a continuous caliche layer is indicative of soils that were undisturbed by human activities at the site.

<u>Excavation Procedures</u>: Prior to initiating the excavation of any trenching segment, the outline of the trench segment was first surveyed by Explosive Ordnance Disposal (EOD) personnel for the presence of unexploded ordnance (UXO) to a depth of at least six feet. The FEREX 4021/MK 26 Forester Locator used by the EOD personnel is capable of detecting a 40 mm artillery projectile (one type of ordnance used during munitions training operations at the site) at a depth of up to six feet. At each trenching area, a backhoe was used to excavate two 15-foot long, 3-foot wide, trench segments that intersected to form a single continuous L-shaped trench (Figure 2.6). The initial 15-foot segment of each trench was excavated to its total depth (6, 9, or

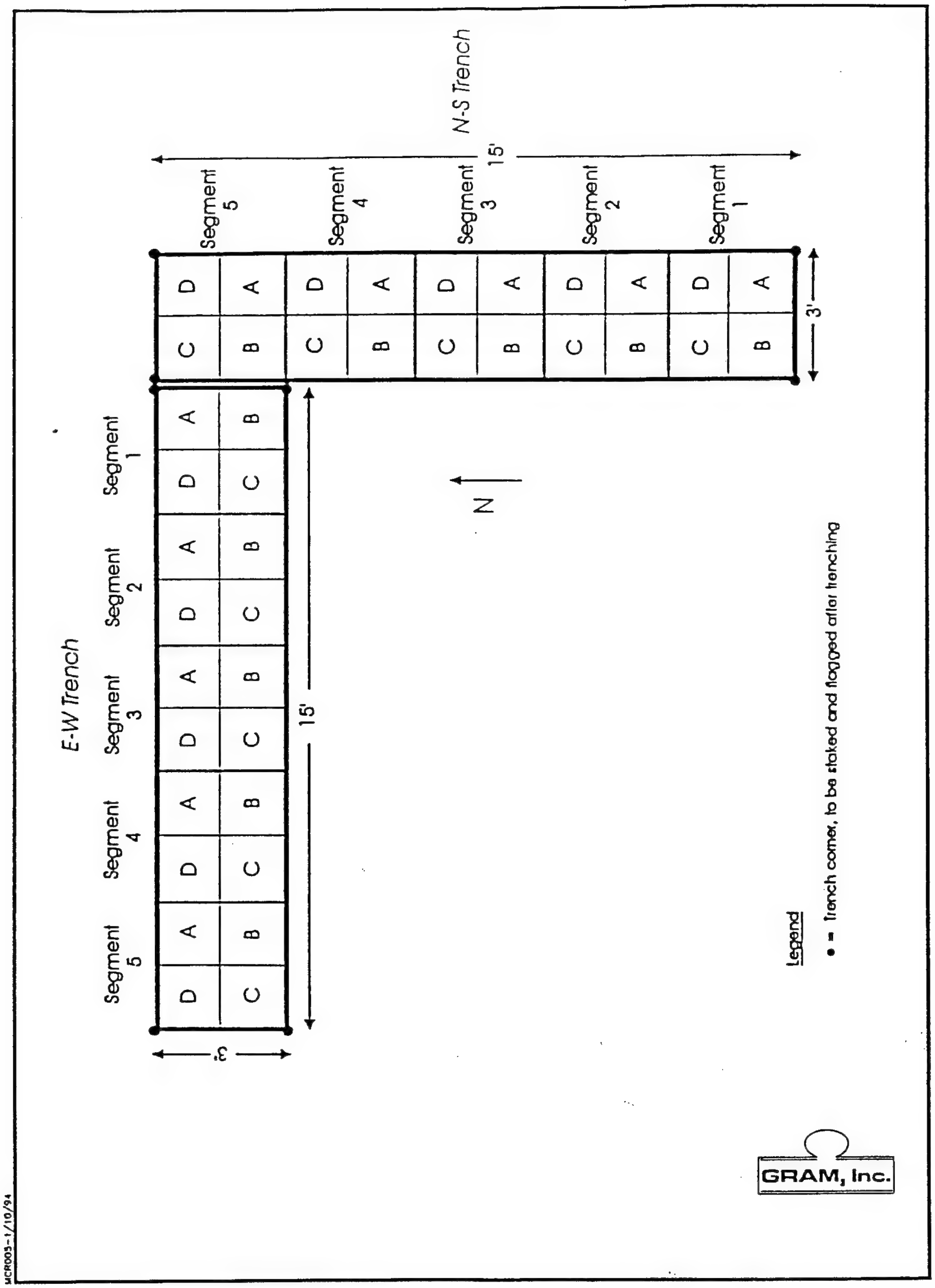

Figure 2.6 General Trenching Configuration

12 feet deep), and then the second 15-foot segment of the trench was excavated. Trenches were excavated in 3-foot lifts to allow clearance by EOD and inspection of the trench walls by the explosives expert and site supervising geologist. When native, undisturbed soils were confirmed in a trench segment, excavation was continued an additional 3-feet and then soil samples were collected. The one exception to this procedure was in the north-south trench segment in Trenching Area 1, where debris halted trenching at 6-feet below ground surface. In that trench segment, native soils were visible under a portion of a buried cement wall, but the cement wall was too large to remove. As a result, trenching was halted without proceeding an additional 3-feet, and samples were collected from soils that were exposed under a portion of the cement wall.

Additionally, the calcium carbonate cement in a caliche layer reduces the permeability of the soil horizon and can serve as a barrier to the downward migration of contaminants into the deeper subsurface. For these reasons, soil sampling during the trenching and hand-augering activities focused on soils above the caliche horizon.

Upon completion of each 3-foot lift in a trench segment, EOD personnel surveyed the trench for UXO. After EOD personnel determined that the trench was clear of UXO, Site Health and Safety Coordinator, the Site Safety Officer allowed the explosives expert and site supervising geologist to enter and inspect the trench. OSHA approved shoring procedures were used at all times when trenching at a depth greater than four feet to maintain a safe excavation for entry. Air monitoring instruments (combustible gas indicator/oxygen level monitor [CGI/O_2] and photoionization detector [PID]) were used to monitor oxygen levels, potentially explosive conditions, and volatile organic vapors in the trench (Standard Operating Procedures for the calibration and use of the instruments are detailed in GRAM, 1994e). The explosives expert first inspected the trench for any indications of explosives residues in the trench wall or floor. Following the explosives inspection, the site supervising geologist entered the trench and recorded detailed descriptions of soil types, color, and any other observations on the Soil Sampling Field Forms. Copies of the soil sampling field forms for trench samples are provided in Appendix B. Soil samples were then collected from the trench sidewalls.

Upon completion of each trench segment and prior to initiating any further excavations, excavated materials were placed back in the trench using the backhoe. The corners of each trench segment were numbered and marked so that the trench could be located and surveyed at the end of the field program. When the field screening task was completed, the soil waste was returned to the appropriate trenching location.

Sampling Procedures: For each 3-foot lift, soil samples were collected for field screening and laboratory analysis after the activities described above were completed. If potential explosives residues were identified by the explosives expert during excavation, soil samples were collected from the trench sidewalls containing the residues. Otherwise, samples were collected from the trench sidewalls at pre-determined locations to achieve a broad coverage of soils in the trench segment. As shown in Figure 2.6, the N-S and E-W trenches were divided into five segments, each of which was subdivided into four quadrants. A total of five samples were collected upon completion of each lift. The following sampling strategy was generally followed:

Lift	Segment/Quadrant to be Sampled
3 feet	1A, 2B, 3C, 4D, 5A
6 feet	1B, 2C, 3D, 4A, 5B
9 feet	1C, 2D, 3A, 4B, 5C
12 feet	1D, 2A, 3B, 4C, 5D

For trench segments that did not reach a depth of 12 feet, additional samples were collected from the shallower sidewalls to obtain a total of 20 samples per trench segment. The Soil Sampling Field Forms (Appendix B) and Table 2.2 contain further details on the exact locations of each soil sample collected from each trench.

Samples were collected using decontaminated stainless steel scoops and bowls (with sufficient sample volume for two complete laboratory analyses and all field screening analyses - approximately 2 to 3 pounds), placed in labeled zip-lock plastic bags, placed on ice in coolers, and sent to the field laboratory for storage and field screening. All sampling equipment (scoops, bowls, spoons) was decontaminated between the collection of each sample. The backhoe was decontaminated after completion of each trenching area. Detailed Standard Operating Procedures for Surface Soil Sampling and Equipment Decontamination/Waste Management that were followed during the trenching activity are presented in GRAM, 1994e. Table 2.2 provides the number of soil samples that were collected from each trench for field screening, and the total number of samples from each trench that were sent to the laboratory for analysis.

2.2.2.2 Hand Augering

A total of 152 soil samples were collected from 13 on-site hand-augering areas and two off-site sampling locations. This section describes the augering procedures and sampling methods used during the hand-augering activity.

Augering Procedures: Prior to hand-augering in an area, all hand-auger sampling locations were staked. Each hand-auger sampling location was then surveyed by EOD personnel for the presence of UXO to a depth of at least 6 feet below ground surface. The FEREX 4021/MK 26 Forester Locator used by the EOD personnel is capable of detecting a 40 mm projectile (one type of ordnance used during munitions training operations at the site) at a depth of 6 feet below the instrument. If the EOD team detected buried debris, they used their metal detection device to assist sampling personnel in finding an acceptable alternative location close to the original location. A PID monitoring instrument was used to continuously monitor for volatile organic vapors in each augered borehole during augering and sampling. A hand-auger, with a 2 ½-inch diameter auger bit and a regular hollow auger head, was used to auger in six-inch increments to depths of approximately 6 feet (or into confirmed native soils). Soil samples from each 6-inch increment were removed from the auger bit by striking the outside of the bit with a hammer. After each 6-inch augering interval, the sampling team recorded detailed descriptions of soil types, color, and any other observations on the Soil Sampling Field Forms (copies of completed Soil Sampling Field Forms for hand auger samples are presented in Appendix C).

Soil samples for analysis were generally collected starting at 2 feet to 3 feet below ground surface and continuing to between 5 and 6 feet below ground surface. Hand-auger samples were collected from the subsurface, rather than from the ground surface, because contaminants of concern in subsurface samples would probably be less affected by oxidation/degradation processes. An easily identifiable carbonate cement (caliche) layer which may serve as a barrier for contaminant migration, was usually present between 3 and 5 feet below ground surface. As a result, soil sampling intervals varied so that the bulk of each sample collected was from soil directly above the caliche layer while at least some of each sample was collected from soils within the caliche layer.

If sufficient soil volume could not be obtained from one borehole, an additional borehole(s) was augered directly adjacent (within one foot, if possible) to the first borehole. If debris was encountered that made it impossible to auger to 6 feet and/or to collect sufficient sample volume, the hole was abandoned and an alternate borehole was augered within a reasonable distance such

that the HE test targeted by the sample location was still sampled. At approximately one-third of the hand-auger sampling locations, the sampling personnel had to deviate augering to a total depth of 6 feet usually because of obstructions in the borehole. Deviations from the Final Work Plan (GRAM, 1994e) in sample location and to depth were sometimes necessary to provide sufficient soil volume and/or to improve the quality of soil samples collected. The deviations were documented on the Soil Sampling Field Forms.

Upon completion of a borehole, augered soil materials not collected for analysis were placed back in the borehole. The borehole location was then numbered and marked and was later surveyed at the end of the field program. Upon completion of the field screening task, all residual soil waste remaining from each hand-auger sampling location was returned to the appropriate borehole location.

Sampling Procedures: A soil sample with sufficient sample volume for two complete laboratory analyses and all field screening analyses, approximately 2 to 3 pounds, was collected from approximately the 3- to 6-foot interval of each augered borehole. The Soil Sampling Field Forms in Appendix C contain exact sample intervals for each soil sample. The soil sample was then placed in a stainless steel bowl, mixed thoroughly using a stainless steel scoop to obtain a homogeneous combination of soils from the entire sampling interval, containerized in labeled zip-lock plastic bags, placed on ice in a cooler, and sent to the field laboratory for storage and field screening. All sampling equipment (hand-augers, scoops, bowls, spoons) was decontaminated between samples.

Detailed Standard Operating Procedures for surface soil sampling, equipment decontamination and waste management procedures that were followed during the hand-augering activity are presented in the Standard Operating Procedures for Equipment Decontamination/Waste Management (GRAM, 1994e). Table 2.4 summarizes the information for each soil sample that was collected from the hand-augering areas and identifies the samples that were sent to the laboratory for analysis (shaded entries).

2.3 Surface Water Sampling

Surface water sampling was included in the Phase II EBS field activities as part of an addendum to the initial work scope. The goal of surface water sampling in the playa area was to determine if any existing soil contamination at McCormick Ranch might be mobilized in surface water after a

precipitation event. The mobilization of contaminants as either disolved species or suspended sediment by surface waters could result in a concentration of contaminants in ponded surface waters on the site, particularly in the playa area. It might also cause contaminants present to be transported with runoff from the site to the proposed Mesa Del Sol development area to the west, and to the south onto the Isleta Pueblo. Additionally, it is possible that ponded water in the playa could, under rare circumstances, serve as a recharge point to the aquifer. For these reasons, a study of contaminant levels in the surface waters was attempted.

2.3.1 Selection of Surface Water Sample Locations

After observing water ponding locations during and after small precipitation events, field personnel identified four potential sampling locations within the boundaries of the playa in the south-central portion of the McCormick Ranch site, and two potential upgradient sampling locations along a road approximately 2 miles east of the site. The locations appeared to be the best available sites to obtain sufficient quantities of fresh rainfall runoff for laboratory analysis. When the field program commenced, large ponds of water were present in the playa area and were being used by livestock. However, the water had obviously been ponded for quite some time as indicated by the algae growing on its surface. It was decided that the existing ponds were not acceptable sampling locations, because the water chemistry may have been altered through evaporation, biological (microbial) degradation, and or/ the presence of livestock. By the end of the field program, when little rain had fallen at the site over a 5 week period, all of the ponds were muddy but contained no water. One surface water sample was collected at an off-site location.

2.3.2 Surface Water Sampling Methods

This section describes procedures that were used during attempts to collect surface water samples, although only one surface water sample was collected. It summarizes the detailed water sampling methods and procedures that were presented in the Field Sampling Plan (GRAM, 1994c) and Standard Operating Procedures (GRAM, 1994e), and that were followed during the sampling activities.

Within one hour of a rainfall event, attempts were made to collect ponded water. A peristaltic pump with decontaminated Tygon tubing was used to pump the ponded water through a 0.45 micron filter into pre-preserved sample bottles. Because of the sediment in the water, the 0.45 micron filters clogged quickly and were only used for the collection of samples for metals analysis. Field measurements of temperature, pH, and conductivity were made on a sample of the surface water, and the measurements were recorded on the Water Sampling Field Form. A copy of the Water Sampling Field Form for the one surface water sample collected is presented in Appendix D. The filled sample bottles were then placed on ice in a cooler and transported to the field laboratory for storage.

3.0 SAMPLE ANALYSIS

3.1 Field Screening

Field screening activities were performed on up to 310 soil samples from the McCormick Ranch site (Table 3.1). The goal of the field-screening activity was to optimize the use of laboratory analyses by pre-screening soil samples collected in the field and using the screening results to select samples for laboratory analysis. Specifically, soil samples were screened for TNT and its degradation products, nitrates, PETN, SVOCs and radioactivity (alpha, beta, and gamma) (Table 3.1). A description of the field screening methods is summarized below.

Table 3.1 Field Screening Methods

ANALYTE	FIELD SCREENING METHOD	NUMBER OF SAMPLES
TNT	ENSYS (IMMUNOASSAY)	300
PETN	THIN LAYER CHROMATOGRAPHY	305
NITRATE	HACH N-TRAK (COLORIMETRIC)	300
SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCs)	THIN LAYER CHROMATOGRAPHY	305
RADIOACTIVITY ALPHA BETA AND GAMMA	 LUDLUM 61 AIR PROPORTIONAL COUNT RATE METER; MODEL TBM-3S MICRO-R METER WITH A GEIGER-MUELLER DETECTOR	310

3.1.1 TNT Screening

Field screening for TNT and its degradation products was performed using a commercially available immunoassay test kit that provides a quantitative, colorimetric analysis. The test kit is manufactured by Ensys, Incorporated and conforms to EPA SW846 draft Method 8515 for quantitative field analysis of TNT and TNT degradation products. A total of 300 soil samples were screened for TNT using this procedure. From these, 40 samples were sent to Quanterra Environmental Services, in California, for quantitative analysis for explosives (including TNT and its degradation products) by method SW8330.

3.1.2 PETN and Semi-Volatile Organic Compound (SVOC) Screening

Field screening for PETN and SVOCs was performed using thin layer chromatography (TLC). TLC is a simple and relatively inexpensive on-site analytical technique that can be used for the analysis of soil samples for semi- and non-volatile organic compounds. The TLC method can be used to screen for a number of contaminants, including PETN, gasoline residues, oil, grease, mineral oil, PCBs, phthalates, pesticides, and herbicides. TLC is commonly used as a qualitative field screening tool for the detection of hydrocarbon contamination in soil and water samples. TLC is a solid-liquid chromatographic procedure in which the liquid phase (solvent) is used to carry the analyte (solute) through the porous solid medium (silica gel coating on a glass slide). The analytes are carried through the porous solid by the liquid. As the analytes move up the slide, they partition between the solid and liquid phases. Analytes strongly attracted to the solid phase will remain on the solid longer, and move more slowly along the slide than analytes that are less strongly attracted. For the field screening conducted for the Phase II EBS, the presence or absence of any semi- or non-volatile organic compound in a soil sample was identified using this method. The method was used to screen 305 soil samples for PETN and SVOCs limiting the use of more expensive analytical laboratory procedures. A total of 40 samples was sent to the contract laboratory, Quanterra Environmental Services, Sacramento, California, for PETN and nitroglycerine analysis by method SW8321, and 20 samples were sent for SVOC analysis by method SW8270.

3.1.3 Nitrate Screening

Field screening for nitrates was performed with the N-Trak soil test kit that provides a quantitative, colorimetric analysis. The test kit is manufactured by Hach, Incorporated and is capable of detecting nitrate concentrations in soil down to 1 ppm. The method is accurate to +/- 2 ppm in the range of 10 to 30 ppm concentration, and somewhat less accurate outside this range. The purpose of soil nitrate field screening was to provide a quantitative evaluation of nitrate in soil samples. A total of 300 soil samples were analyzed for nitrate concentration using the N-Trak test kits. From these, 40 samples were sent to Quanterra Environmental Services for quantitative analysis by EPA method E353.2.

3.1.4 Radioactivity Screening

Field screening for radioactivity was performed using a Ludlum 61 Air Proportional Count Rate Meter (alpha (α)), and a Technical Associates Model TBM-3S Micro-R Meter with a Geiger-Mueller (G-M) detector (beta (β) and gamma (γ)). These instruments were provided, maintained, and calibrated by the Kirtland AFB Bioenvironmental Division. Radiological measurements were made within one to two centimeters of the soil sample through the open mouth of the zip-lock plastic bag. Instrument readings for each sample were recorded in a designated logbook. A total of 310 soil samples were screened for alpha, beta and gamma radioactivity.

Seventeen composite samples were then prepared and transferred to the Kirtland AFB Bioenvironmental Division for radiological analysis at Armstrong Laboratory. Four composite samples were prepared from the trenching areas, and 13 composite samples were prepared from the following hand-auger sampling areas: Geophysical Area 1, Geophysical Area 2, Geophysical Area 3, Geophysical Area 4, Geophysical Area 5, Gravel Pit Area, DIP 5 Area, Generator Site, Fuselage Area, Art Test Area, Hi Fi Test Bed A, DCT HEST Area, and SSTM Add-On Area.

The composite samples were prepared by consolidating equal amounts of soil from each of the sample bags for a given sampling area, for a total of two kilograms of soil. The composite soil samples were placed in one-gallon, wide-mouth, polyethylene containers.

3.1.5 Quality Assurance (QA)/Quality Control (QC) Procedures

Rigorous QA/QC procedures were followed throughout the field screening activities to ensure that data of known quality were collected. More specifically, QA/QC procedures evaluated precision, accuracy, representativeness, comparability, and completeness (PARCC parameters) of the data and data collection process. Table 3.2 lists the QA/QC sample types and sample frequency required for each of the field screening methods. A more detailed discussion of QA/QC procedures for field screening is presented in Attachment 2.

Field screening worksheets accompanied each batch of samples that was collected and are presented in Appendix F. Field screening analyses and results were recorded on the field screening worksheets using the unique sample identifiers for each sample. Upon completion of the sample screening, the laboratory technician verified that the information was correct and then signed and dated each form.

Laboratory logbooks were also maintained to include information regarding field screening procedures, preparation of standards, sample preparation, sample spotting, equipment cleaning, TLC plate preparation, and sample analysis. Other pertinent information recorded included date, time, sample numbers, analytical results, and any unusual incidents or circumstances (e.g., accidental spill). All completed pages of the laboratory logbooks for each days activities were signed by the laboratory technician at the end of each day.

Table 3.2 Field Screening QA/QC Sample Frequency

SAMPLE TYPE	TNT	PETN	NITRATES	SVOCs
SOIL BLANK	1/40*	1/40	NA	NA
METHOD BLANK	1/20	1/20	1/20	1/20
MATRIX SPIKE	NA	1/20	NA	1/20
DUPLICATE	1/20	1/20	1/20	1/20
STANDARD**	1/Batch	Minimum of 2/Batch	3/Day	Minimum of 2/Batch

NA -- Not Applicable

* 1/40 -- One QA/QC sample was analyzed for every 40 environmental samples analyzed

**Number of standards run with each type of analyses

3.2 Laboratory Analysis

Based on the results of the field screening, selected samples were sent to the analytical laboratories for quantitative analysis for explosives, nitrate+nitrite, SVOCs, metals, cyanide, and specific radionuclides by gamma spectrometry. All analyses were performed in accordance with EPA methods and USAF procedures. The results of the field screening were used to select soil samples with the highest probability of containing contaminants. The criteria used to select samples to be sent to the analytical laboratory for analysis are summarized in Table 3.3. When field screening identified fewer potentially contaminated samples than were to be sent to the laboratory for analysis (for explosives, nitrate + nitrite, and SVOCs), the supervising geologist on-site selected additional samples to be sent to the laboratory after reviewing field notes. Further details on sample selection procedures are available in the Field Sampling Plan (GRAM 1994c). The number of samples sent to the analytical laboratory for each method is listed in Table 3.4.

3.2.1 Laboratory Analytical Methods

The contaminants of concern were determined during the Phase I EBS investigation by evaluating the materials historically used during testing at McCormick Ranch. A list of the explosives and other materials of concern, used in testing at McCormick Ranch, is presented in the Phase I EBS Final Report (LATA, 1993). The appropriate analytical methods necessary for the proper detection/identification of the selected contaminants of concern were then selected. The Practical Quantitation Limits (PQL) were then specified as listed in the AFCEE Handbook for IRP RI/FS (USAF, 1993). The PQL is defined as the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. All results above the specified PQLs are reported as quantitative. Table 3.5 lists the analytes in soil and water samples from McCormick Ranch, the laboratory analytical methods used, and the PQLs for each analyte. For some of the metals of concern, (e.g., arsenic, lead, mercury, selenium, and thallium) specific analytical methods were used to achieve lower PQLs. The analytical laboratory was instructed to report any compounds detected above the method detection limit (MDL). The MDL is defined as the concentration at which there is 99% confidence that the compound is present, but the concentration cannot be determined. Values between the MDL and the PQL are estimates, and are reported with a "J" qualifier. Data qualifiers and their definitions are listed in Table 3.6.

Table 3.3 Sample Selection Criteria

ANALYTE	SELECTION CRITERIA
Explosives	Samples with the highest PETN and/or TNT concentrations found in field screening for the area. Where possible, samples were sent from sampling locations which had both TNT and PETN hits. Where possible, at least one sample was sent with a PETN hit and one sample with a TNT hit. If potential explosive residues were identified in soil samples but neither PETN or TNT were detected, samples to be sent to the analytical laboratory were identified by the supervising geologist. If no explosive hits were found in an area, samples were sent from sampling locations with the highest nitrate concentrations or at the discretion of the supervising geologist.
Nitrate + Nitrite	Samples with the highest nitrate concentrations found in field screening for the area. If no nitrates were found in field screening for the area (i.e., below detection limits), then nitrate samples were sent from the same sampling locations from which explosives samples were sent to the laboratory.
SVOCs	Samples with the highest hydrocarbon concentrations found in field screening for the area. If no hydrocarbons were found, then SVOC samples were sent from the same sampling locations from which explosives samples were sent to the laboratory.
Metals	Samples to be sent from the same locations from which explosives samples were sent to the laboratory, with the following exceptions: (1) No metal samples were sent from geophysical area 3 even though five explosives samples were sent, and (2) Five metal samples were sent from the gravel pit area even though no explosives samples were sent to the laboratory.
Cyanide	Samples to be sent from the same locations from which explosives samples were sent to the laboratory.
Radiation/ Radionuclides	Samples were sent if alpha, beta or gamma readings were above background levels. Otherwise one composite soil sample from each trenching and hand augering area was sent to the laboratory.

Table 3.4 Summary of Laboratory Analysis

ANALYTE	METHOD	SOURCE		TOTAL
		TRENCHING	AUGERING	
Arsenic	SW7060	16	24	40
Lead	SW7421	16	24	40
Mercury	SW7470	16	24	40
Selenium	SW7740	16	24	40
Thallium	SW7841	16	24	40
Cyanide	SW9012M	16	24	40
ICP Metals	SW6010	16	24	40
SVOCs	SW8270	3	17	20*
Explosives	SW8330	16	24	40
Explosives	SW8321	16	24	40
Nitrate + Nitrite	E353.2	16	24	40

* 20 samples were submitted, the analytical laboratory omitted two samples in the login process and did not perform the requested analysis.

Table 3.5 Laboratory Analytical Methods

Method	Parameter	Water		Soil	
		PQL	Unit	PQL	Unit
SW7060	Arsenic	0.005	mg/L	0.5	mg/kg
SW7421	Lead	0.005	mg/L	0.5	mg/kg
SW7471	Mercury	0.001	mg/L	0.1	mg/kg
SW7740	Selenium	0.005	mg/L	0.5	mg/kg
SW7841	Thallium	0.002	mg/L	0.5	mg/kg
SW9012	Cyanide	0.01	mg/L	0.5	mg/kg
E353.2	Nitrate + Nitrite	0.05	mg/L	0.3	mg/kg
Inductively Coupled Plasma (ICP) Screen for Metals SW6010	Aluminum	0.5	mg/L	50	mg/kg
	Antimony	0.4	mg/L	15	mg/kg
	Barium	0.02	mg/L	10	mg/kg
	Beryllium	0.003	mg/L	1	mg/kg
	Cadmium	0.04	mg/L	0.5	mg/kg
	Calcium	0.5	mg/L	100	mg/kg
	Chromium	0.07	mg/L	5	mg/kg
	Cobalt	0.07	mg/L	5	mg/kg
	Copper	0.06	mg/L	5	mg/kg
	Iron	0.10	mg/L	5	mg/kg
	Magnesium	0.5	mg/L	100	mg/kg
	Manganese	0.02	mg/L	2	mg/kg
	Molybdenum	0.08	mg/L	10	mg/kg
	Nickel	0.15	mg/L	15	mg/kg
	Potassium	5.0	mg/L	500	mg/kg
	Silver	0.07	mg/L	5	mg/kg
	Sodium	0.3	mg/L	500	mg/kg
	Vanadium	0.08	mg/L	10	mg/kg
	Zinc	0.02	mg/L	2	mg/kg

Table 3.5 Laboratory Analytical Methods (continued)

Method	Parameter	Water		Soil	
		PQL	Unit	PQL	Unit
Semivolatile	**Base/Neutral Extractibles**				
Organic					
Compounds	Acenaphthene	10	µg/L	0.7	mg/kg
SW8270	Acenaphthylene	10	µg/L	0.7	mg/kg
	Anthracene	10	µg/L	0.7	mg/kg
	Benzoic acid	10	µg/L	0.7	mg/kg
	Benzo (a) anthracene	10	µg/L	0.7	mg/kg
	Benzo (b) fluoranthene	10	µg/L	0.7	mg/kg
	Benzo (g,h,i) perylene	10	µg/L	0.7	mg/kg
	Benzo (a) pyrene	10	µg/L	0.7	mg/kg
	Benzyl alcohol	20	µg/L	1.3	mg/kg
	bis (2-	10	µg/L	0.7	mg/kg
	Chloroethoxy)methane	10	µg/L	0.7	mg/kg
	bis (2-Chloroethyl) ether	10	µg/L	0.7	mg/kg
	bis (2-Chloroisopropyl)	10	µg/L	0.7	mg/kg
	ether	10	µg/L	0.7	mg/kg
	bis (2-Ethylhexyl) phthalate	10	µg/L	0.7	mg/kg
	4-Bromophenyl phenyl ether	20	µg/L	0.7	mg/kg
	Butylbenzyl phthalate	10	µg/L	1.3	mg/kg
	4-Chloroaniline	10	µg/L	0.7	mg/kg
	2-Chloroanphthalene	10	µg/L	0.7	mg/kg
	4-Chlorophenyl phenyl ether	10	µg/L	0.7	mg/kg
	Chrysene	10	µg/L	0.7	mg/kg
	Dibenz (a,h) anthracene	10	µg/L	0.7	mg/kg
	Dibenzofuran	10	µg/L	0.7	mg/kg
	Di-n-butylphthalate	10	µg/L	0.7	mg/kg
	1,2-Dichlorobenzene	10	µg/L	0.7	mg/kg
	1,3-Dichlorobenzene	20	µg/L	0.7	mg/kg
	1,4-Dichlorobenzene	10	µg/L	1.3	mg/kg
	3,3'-Dichlorobenzidine	10	µg/L	0.7	mg/kg
	Diethyl phthalate	10	µg/L	0.7	mg/kg
	Dimethyl phthalate	10	µg/L	0.7	mg/kg
	2,4-Dinitrotoluene	10	µg/L	0.7	mg/kg
	2,6-Dinitrotoluene	10	µg/L	0.7	mg/kg
	Di-n-octyl phthalate	10	µg/L	0.7	mg/kg
	Fluoranthene				
	Hexachlorobenzene				

Table 3.5 Laboratory Analytical Methods (continued)

Method	Parameter	Water		Soil	
		PQL	Unit	PQL	Unit
Semivolatile Organic Compounds SW8270 (Continued)	**Base/Neutral Extractibles (cont)**				
	Hexachlorobutadiene	10	µg/L	0.7	mg/kg
	Hexachlorocyclopentadiene	10	µg/L	0.7	mg/kg
	Hexachloroethane	10	µg/L	0.7	mg/kg
	Indeno (1,2,3-c,d) pyrene	10	µg/L	0.7	mg/kg
	Isophorone	10	µg/L	0.7	mg/kg
	2-Methylnaphthalene	10	µg/L	0.7	mg/kg
	Naphthalene	10	µg/L	0.7	mg/kg
	2-Nitroaniline	50	µg/L	3.3	mg/kg
	3-Nitroaniline	50	µg/L	3.3	mg/kg
	4-Nitroaniline	50	µg/L	3.3	mg/kg
	Nitrobenzene	10	µg/L	0.7	mg/kg
	N-Nitrosodiphenylamine	10	µg/L	0.7	mg/kg
	N-Nitrosodipropylamine	10	µg/L	0.7	mg/kg
	Phenanthrene	10	µg/L	0.7	mg/kg
	Pyrene	10	µg/L	0.7	mg/kg
	1,2,4-Trichlorobenzene	10	µg/L	0.7	mg/kg
Semivolatile Organic Compounds (Concluded) SW8270	**Acid Extractables**				
	Benzoic acid	50	µg/L	1.6	mg/kg
	4-Chloro-3-methylphenol	20	µg/L	1.3	mg/kg
	2-Chlorophenol	10	µg/L	0.3	mg/kg
	2,4-Dichlorophenol	10	µg/L	0.3	mg/kg
	2,4-Dimethylphenol	10	µg/L	0.3	mg/kg
	4,6-Dinitro-2-methylphenol	50	µg/L	3.3	mg/kg
	2,4-Dinitrophenol	50	µg/L	3.3	mg/kg
	2-Methylphenol	10	µg/L	0.3	mg/kg
	4-Methylphenol	10	µg/L	0.3	mg/kg
	2-Nitrophenol	10	µg/L	0.3	mg/kg
	4-Nitrophenol	50	µg/L	1.6	mg/kg
	Pentachlorophenol	50	µg/L	3.3	mg/kg
	Phenol	10	µg/L	0.3	mg/kg
	2,4,5-Trichlorophenol	50	µg/L	3.3	mg/kg
	2,4,6-Trichlorophenol	10	µg/L	0.3	mg/kg

Table 3.5 Laboratory Analytical Methods (concluded)

Method	Parameter	Water		Soil	
		PQL	Unit	PQL	Unit
Explosives SW8330	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	13	µg/L	2.2	mg/kg
	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	14	µg/L	1	mg/kg
	1,3,5-Trinitrobenzene (TNB)	7.3	µg/L	0.25	mg/kg
	1,3-Dinitrobenzene (DNB)	4	µg/L	0.25	mg/kg
	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	44	µg/L	0.65	mg/kg
	Nitrobenzene	7	µg/L	0.26	mg/kg
	2,4,6-Trinitrotoluene	6.9	µg/L	0.25	mg/kg
	2,4-Dinitrotoluene	5.7	µg/L	0.25	mg/kg
	2,6-Dinitrotoluene	9.4	µg/L	0.26	mg/kg
	o-Nitrotoluene	12	µg/L	0.25	mg/kg
	m-Nitrotoluene	7.9	µg/L	0.25	mg/kg
	p-Nitrotoluene	8.5	µg/L	0.25	mg/kg
Explosives SW8321	Nitroglycerin	50	µg/L	0.5	mg/kg
	PETN	50	µg/L	0.5	mg/kg

PQL - Practical Quantitative Limit

Table 3.6 Analytical Laboratory Data Qualifiers

QUALIFIERS	DEFINITION
B	Compound is also detected in the laboratory method blank.
G	Raised reporting limit due to matrix interference.
J	Result is detected below the PQL but greater than the MDL. This is an estimated value since the precision and accuracy of the method at that level are not defined.
p	Reporting limit raised due to a dilution necessitated by initial post-digestion spike recovery of less than 40% due to matrix interference.
Q	Reporting limit raised due to high level of another analyte in the sample.
q	Post-digestion spike recovery fell between 40% and 85% due to matrix interference.
R	Raised reporting limit due to high analyte level.

3.2.2 Quality Assurance (QA)/Quality Control (QC) Requirements

Quality control data provides information for determining if the data are valid, and quality assurance procedures are followed to ensure that data of consistent quality are collected.
The following QA/QC procedures provided the primary basis for evaluating data quality for this project:

- Field duplicate sample analyses
- Matrix spike and matrix spike duplicate analyses
- Equipment blank analyses
- Ambient blank analyses
- Adherence to holding-time requirements
- Laboratory blank and control-sample analyses
- Sample temperature
- Chain-of-Custody.

The basic unit for analytical quality control is the analytical batch. The analytical batch is defined as samples which are analyzed together with the same method sequence, the same lots of reagents, and the same manipulations common to each sample (within the same time period or in continuous sequential time periods). The maximum size of an analytical batch is 20 samples and samples in each batch should be of similar composition.

Table 3.7 summarizes laboratory QA/QC samples for each analytical method. A more detailed discussion of laboratory QA/QC samples is presented in Attachment 2.

Table 3.7 Summary of Laboratory QA/QC Samples

ANALYTE	METHOD	ENVIRONMENTAL SAMPLES	DUPLICATE SAMPLES	MS/MSD
Arsenic	SW7060	42*	4	2
Lead	SW7421	42*	4	2
Mercury	SW7470	42*	4	2
Selenium	SW7740	42*	4	2
Thallium	SW7841	42*	4	2
Cyanidê	SW9012M	40	4	2
ICP Metals	SW6010	42*	4	2
Semi-Vocs	SW8270	18**	2	1
Explosives	SW8330	40	4	2
Explosives	SW8321	40	4	2
Nitrate + Nitrite	E353.2	42*	4	2

* 40 on-site samples + 2 background samples.

** 20 on-site samples were submitted, however, the analytical laboratory omitted two samples in the log-in process and did not perform the requested analysis for the two samples.

4.0 RESULTS OF FIELD PROGRAM

4.1 Geophysical Survey Results

Geophysical surveys at McCormick Ranch were performed to identify and map buried debris and disturbed soils related to known historical HE tests. Magnetic and EM 31 data provide information on the physical properties of soils and buried targets, and subsequent GPR surveys identified disturbed soils and provided information on the shape and size of the buried targets to a maximum depth of approximately 15 feet. Instrument responses and interpretations are presented below in Table 4.1.

Table 4.1 Geophysical Instruments Response and Corresponding Interpretations

INSTRUMENT RESPONSE	INTERPRETATION
Magnetic Anomaly - yes EM 31 In-Phase Anomaly - yes or no EM 31 Quadrature Anomaly - yes or no	Indicates metal object(s), including ferrous metal (steel and/or iron). If there is no associated EM 31 anomaly, the target is buried beyond the range of detection, or the target size is too small for detection by the EM31 instrument.
Magnetic Anomaly - no EM 31 In-Phase Anomaly - yes EM 31 Quadrature Anomaly - yes	Indicates non-ferrous metal object(s)
Magnetic Anomaly - no EM 31 In-Phase Anomaly - no EM 31 Quadrature Anomaly - yes	Indicates conductive soils/materials
GPR Reflector	Confirms buried targets/disturbed soils/ stratigraphic horizons

Surface debris maps were prepared for each geophysical survey area so that anomalies related to surface debris were identified during the interpretation. Geophysical data and the surface debris maps are presented in a technical memorandum presenting a preliminary Data Report on the Geophysical Surveys (GRAM, 1994d). Details on field operating procedures, calibration, QA/QC, and data collection activities are discussed in the work plan for the Geophysical Surveys (GRAM,1993). Results of the geophysical investigations are summarized in Table 2.3, and

interpretive maps based upon the geophysical data are presented in Figures 2.3 to 2.6. The anomalies shown on the interpretive maps are related to buried targets, and correspond to the locations where GPR transects were performed. The anomalies are numbered according to the identifiers in Table 2.3.

4.1.1 Geophysical Area 1

Geophysical Area 1 has dimensions of 400 feet by 500 feet and covers the approximate location of the HEST tests (Figures 2.1 and 2.2). These tests were conducted in 1966, using large quantities of PETN (>20,000 pounds), detonated at burial depths from 10 feet to 30 feet. Only a small amount of surface debris is present in this area. Figure 2.2 presents an interpretive map of the EM 31 and magnetic data for this Area.

Anomaly 1(A) is centered at approximately 370E, 90N, with approximate dimensions of 50 feet (east-west) and >170 feet (north-south) (Figure 2.1 and Table 2.3). This anomaly is related to buried metal, including ferrous metals. GPR profiles indicate that there is a subsurface disturbance (trench or crater) from approximately 10 feet to greater than 15 feet deep, and subsurface cracks associated with this anomaly. Figure 4.1 presents a GPR transect across Anomaly 1(A), showing a covered trench or depression. A broad surface depression is present in this zone, and is interpreted to be related to soil subsidence. This anomalous zone was interpreted to be the location of one of the HEST Tests. Field reconnaissance with people who had first-hand knowledge of testing activities confirmed this interpretation. For these reasons, anomaly 1(A) was selected as the location for Trenching Area 1 (see Section 2.2.1.1).

Anomaly 1(B) is centered at approximately 210E, 220N, and has dimensions of approximately 50 feet (north-south) by 60 feet (east-west) (Figure 2.2 and Table 2.3). This anomaly is related to buried metal, including ferrous metals. GPR profiles in this area indicate that the anomaly is related to a small, discrete buried object from approximately two feet to three feet deep. There was no evidence of trenching or cratering associated with this anomaly.

Anomaly 1(C) is centered at approximately 60E, 270N, and has dimensions of approximately 50 feet (north-south) by 50 feet (east-west) (Figure 2.2 and Table 2.3). This anomaly is related to buried metal, including ferrous metals. GPR profiles over this anomaly identified a covered trench or crater greater than approximately eight feet deep, and subsurface cracks, apparently related to testing activities. Figure 4.2 presents a GPR transect across Anomaly 1(C), showing

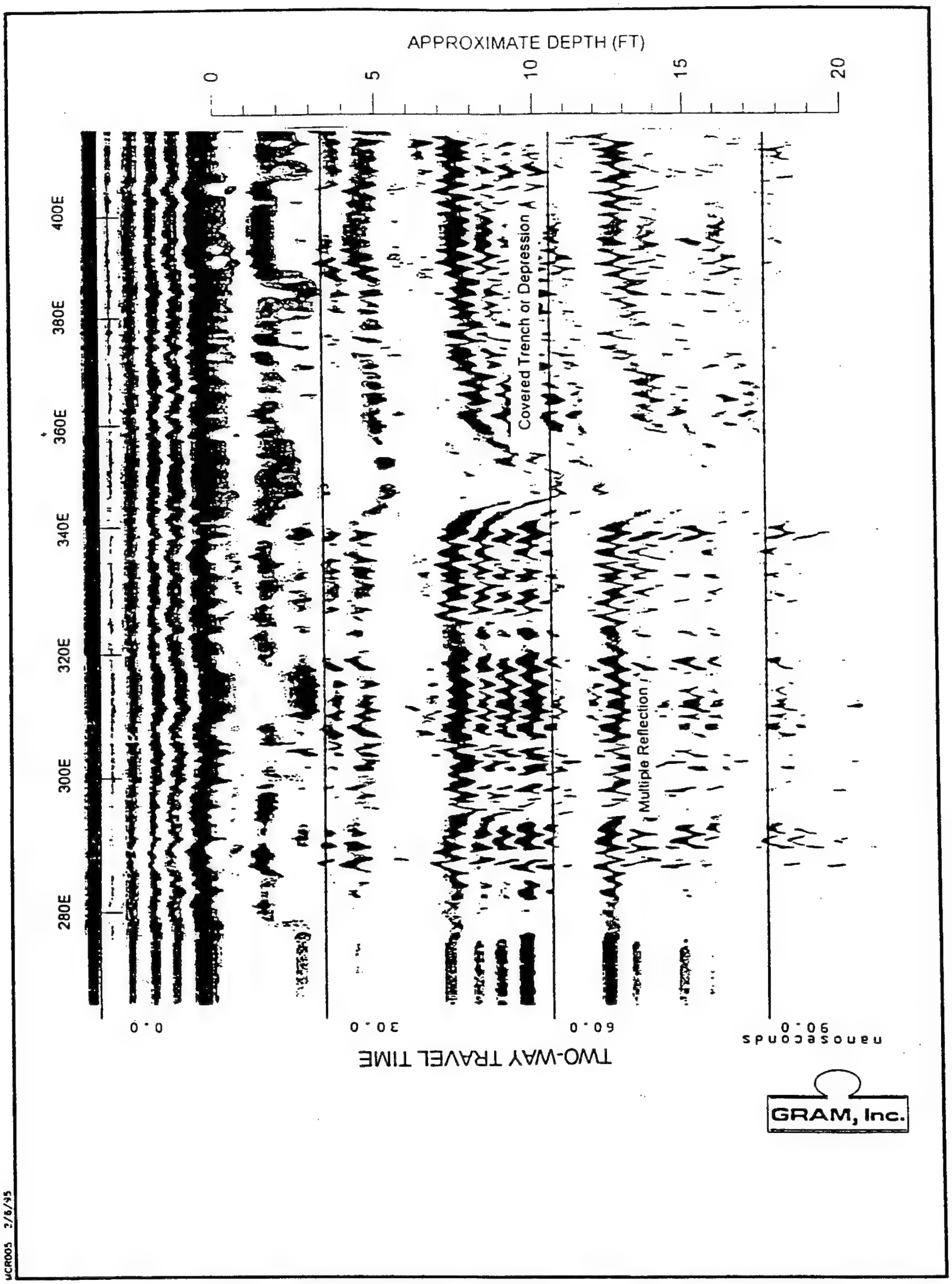

Figure 4.1 **Area 1, Anomaly 1(A): West-East GPR Transect Along Line 140N Showing a Covered Trench or Depression**

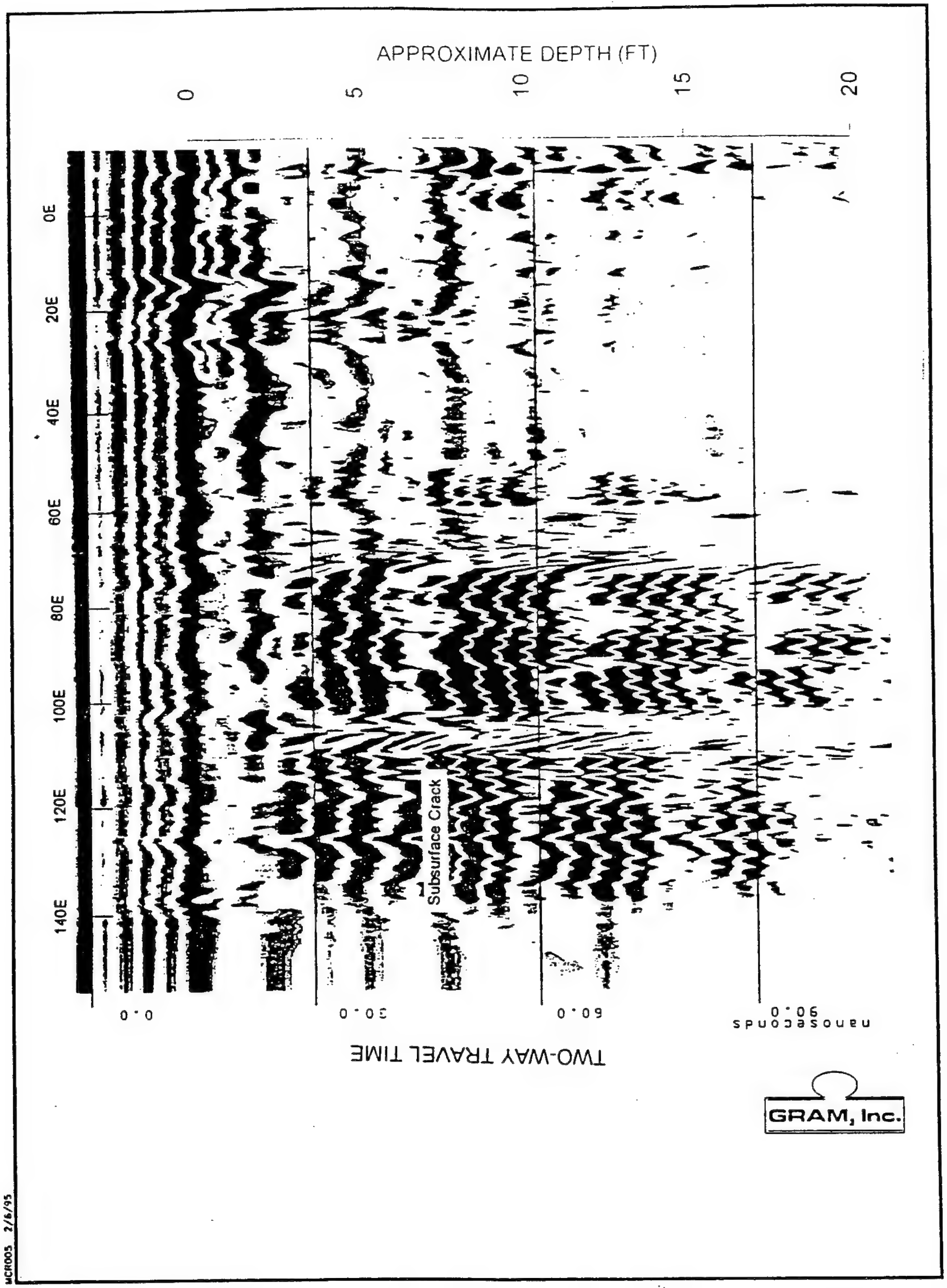

Figure 4.2 **Area 1, Anomaly 1(C): East-West GPR Transect Along Line 260N Showing Subsurface Cracks**

subsurface cracks. A broad surface depression is present in this anomalous zone, and is interpreted to be related to soil subsidence. Field reconnaissance with people who had first-hand knowledge of testing activities confirmed the interpretation that this zone was the location of one of the HEST tests. For these reasons, anomaly 1(C) was selected as the location for Trenching Area 2 (see Section 2.2.1.1).

Anomaly 1(D) is located at approximately 160E, 275N, and has approximate dimensions of five feet (east-west) and 20 feet (north-south) (Figure 2.2 and Table 2.3). This anomaly was detected with the in-phase output of the EM 31 instrument, but not by the magnetometer. This indicates that this anomaly is related to buried, non-ferrous metals. GPR profiles collected over this anomaly showed a small amount of buried debris and some subsurface cracks. This anomaly is interpreted to be related to testing, but no subsurface craters or depressions were identified. This anomalous zone was selected as a location for hand-auger sampling.

4.1.2 Geophysical Area 2

Geophysical Area 2 has dimensions of 500 feet by 500 feet and covers the approximate locations of the Desert Fire, Event Series, Modular Storage Magazine (MSM), Enhanced Blast Munitions (EBM), and Counter Fuel-Air Explosive (FAE) tests (Figures 2.1 and 2.2). These tests were conducted from 1984 to 1992, and involved PETN, fuel oil, and bombs containing TNT. A large amount of surface debris is present in the area, including buried structures, cables, wire, wood, and rebar.

A single anomalous zone, Anomaly 2(A), was detected in the northwest corner of this Area (Figure 2.3). This anomaly is located at approximately 20E, 410N, and has dimensions of greater than 60 feet (east-west) by 75 feet (north-south). This geophysical anomaly was detected with the quadrature component of the EM 31 instrument, which measures soil conductivity. No anomalous readings were present in the magnetic or EM 31 in-phase data in this zone. Therefore, this anomaly is interpreted to be related to conductive, non-metallic materials (i.e., high soil electrical conductivity). GPR profiles collected over this zone show disturbed soils and a subsurface depression, interpreted to be related to a covered trench or crater. A broad surface depression is present in this anomalous zone, and is interpreted to be related to soil subsidence. Although the specific testing activities that created this feature are not known, Anomaly 2(A) was selected as the location for Trenching Area 3 based upon results of the geophysical investigations (see Section 2.2.1.1).

4.1.3 Geophysical Area 3

Geophysical Area 3 has dimensions of 500 feet by 500 feet and covers the approximate locations of the SSTM and BLEST tests (Figures 2.1 and 2.2). These tests were performed using quantities of PETN, fuel oil, and TNT detonated at burial depths of 16 feet to 28 feet. There is a small amount of surface debris scattered across the area, including rebar, metal casings, metal pipes, and wire. Scattered ferrous debris was detected, but no geophysical anomalies related to large buried targets or features were detected in this area.

4.1.4 Geophysical Area 4

Geophysical Area 4 has dimensions of 500 feet by 500 feet and covers the approximate locations of the CHEBS and Mini-Sim Quake tests (Figures 2.1 and 2.2). The CHEBS test was conducted in 1984, and involved detonation of bombs containing explosive compounds that included TNT. The Mini-Sim Quake test was conducted in 1977 and involved over 70 tons of explosives, including TNT and fuel oil. The area contains scattered metal debris on the surface, including wire, rebar, cables, and metal fragments. Figure 2.4 presents an interpretive map of the EM 31 and magnetic data for this area.

Anomaly 4(A) is a large semi-circular anomaly centered at approximately 280E, 370N, with approximate dimensions of 180 feet (east-west) by 130 feet (north-south) (Figure 2.4 and Table 2.3). This anomaly was detected with the EM 31 in-phase measurements, but not with the magnetometer. Therefore, this anomaly is interpreted to be related to buried, non-ferrous metal. GPR profiles collected over this anomalous zone show buried debris and disturbed soils from near the surface to approximately 10 feet deep. Buried debris was detected along the semicircle and in the center. The non-ferrous metal detected in this anomalous zone is interpreted to be wiring and instrumentation related to testing activities. This anomalous zone was selected as a location for Trenching Area 4 (see Section 2.2.1.1).

Anomaly 4(B) is centered at approximately 470E, 210N, with approximate dimensions of greater than 70 feet (east-west) by 80 feet (north-south) (Figure 2.4 and Table 2.4). This anomaly is interpreted to be related to non-ferrous, buried metal. Field reconnaissance following the geophysical surveys identified partially buried copper cables in this anomalous zone. The anomaly was, therefore, interpreted to be related to the cable run, and further investigation of this anomalous zone was not performed.

4.1.5 Geophysical Area 5

Geophysical Area 5 has dimensions of 500 feet by 500 feet and covers the approximate locations of several of the DABS tests (Figures 2.1 and 2.2). The DABS tests were conducted from 1975 to 1985 in concrete lined trenches, using PETN, TNT, and fuel oil. Several steel I-beams, an I-beam structure (hoist), steel plates, concrete pads, and scattered metal debris are present on the surface in this Area. Figure 2.5 presents an interpretive map of the EM 31 and magnetic data for Area 5.

Anomaly 5(A) is centered at approximately 190E, 250N, with approximate dimensions of 220 feet (east-west) by 80 feet (north-south) (Figure 2.5 and Table 2.3). This anomalous zone corresponds to the location of large metal objects on the surface, including an I-beam hoist and several large steel I-beams on the ground surface. However, the geophysical anomaly measured is larger in areal extent than is explained by surface features. GPR profiles identified numerous small buried objects from near the surface to approximately eight feet deep, and additional field reconnaissance identified large amounts of partially buried wires and debris in this zone. This anomalous zone was selected as a location for hand-auger soil sampling.

Anomaly 5(B) consists of six north-south trending small anomalies related to buried, ferrous metal. This anomalous zone is centered at approximately 170E, 350N, with approximate dimensions of 200 feet (east-west) by 50 feet (north-south) (Figure 2.5 and Table 2.3). GPR profiles detected small, buried targets from approximately one feet to two feet in depth, related to two of the six anomalies. This anomalous zone was selected as a location for hand-auger soil sampling.

Anomaly 5(C) is centered at approximately 40E, 450N, with approximate dimensions of 40 feet (east-west) by 45 feet (north-south) (Figure 2.5 and Table 2.3). This anomalous zone is interpreted to be related to buried metal, including ferrous metals. GPR profiles over this anomaly detected two discrete buried targets at an approximate burial depth of three feet to four feet, as shown in Figure 4.3. This anomalous zone was selected as a location for hand-auger soil sampling.

Anomaly 5(D) is centered at approximately 210E, 460N, with approximate dimensions of 60 feet (east-west) by 60 feet (north-south) (Figure 2.5 and Table 2.3). This anomalous zone is interpreted to be related to buried metal, including ferrous metals. GPR profiles over this anomaly did not detect any buried targets.

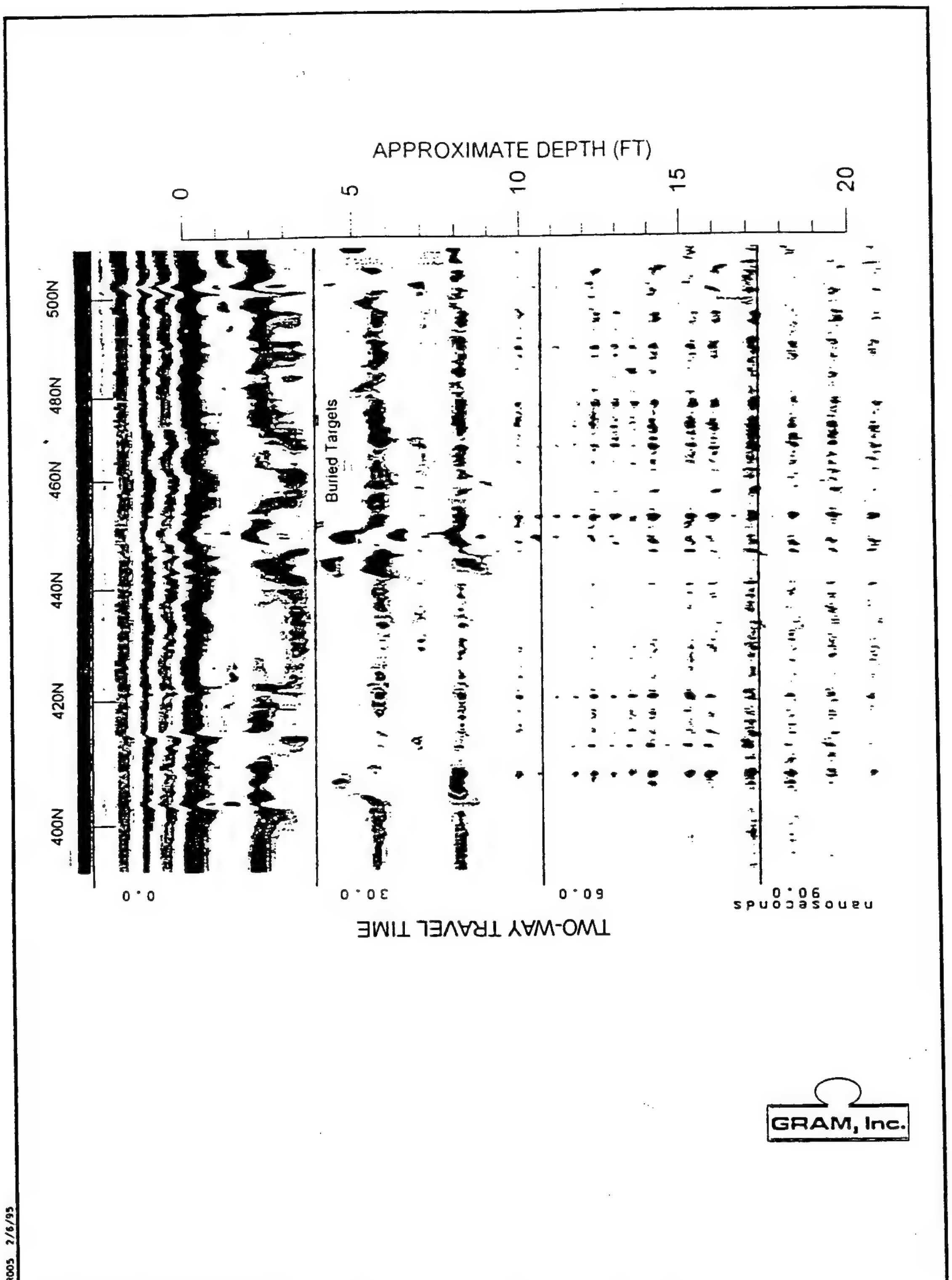

Figure 4.3 Area 5, Anomaly 5(C): South-North GPR Transect Along Line 40E Showing Buried Targets

Two additional small anomalies were identified in Area 5. Anomaly 5(E), centered at approximately 180E, 40N, was determined to be related to a metal object (geophone) on the surface during final field reconnaissance. Anomaly 5(F), centered at 220E, 90N with dimensions of 30 feet (east-west) by 30 feet (north-south), is related to buried metal including ferrous metals (Figure 2.5 and Table 2.3). GPR profiles over this zone identified small, discrete buried targets from the near-surface to approximately two feet deep, but no evidence of trenching or cratering was indicated.

4.1.6 Gravel Pit Area

Interviews and field reconnaissance conducted with people who have first-hand knowledge of testing activities revealed that the gravel pit (shown in Figures 2.1 and 2.2) was historically used for burial of test debris such as metal plates, concrete, cables, wood, and wiring. EM 31 data were collected around the gravel pit, and identified an area containing buried metal in the southwest corner. No grid was established in this area, but anomaly locations were marked in the field with pin-flags. The anomaly identified with the EM 31 instrument is related to buried metal, and has approximate dimensions greater than 75 feet (east-west) by 75 feet (north-south). GPR profiles collected over the anomalous zone identified buried debris just beneath the ground surface. This anomalous zone was selected as an area for hand-auger soil sampling.

4.2 Soil Characteristics

The following sections provide a description of the soils and debris encountered at the trenching and hand-augering locations. Soil descriptions for each location were recorded using Soil Sampling Field Forms (Appendix B and Appendix C). Soil descriptions included lithologic descriptions, Unified Soil Classification System (USCS) codes, color identification (using Munsell Charts), recovery percentages, and any other information deemed pertinent by the on-site sampling personnel.

4.2.1 Soils at Trench Locations

Trenching provided the most detailed view of soils and HE test debris at selected locations at the McCormick Ranch site. By obtaining a cross-sectional view of an area during trenching, rather than obtaining just a small core, soil horizons were more easily identified and the nature of testing at the trenching area better understood. During the excavation of trench segments at Trenching Areas 3 and 4, two soil scientists from William Lettis & Associates, Inc. (WLA, Inc.) were present. WLA is currently performing a geomorphology study of the Kirtland AFB for Sandia National Laboratories, and requested access to McCormick Ranch to examine trench sidewalls to gain additional soil morphology information for their study. Their presence during trenching at McCormick Ranch was permitted by Phillips Laboratory management. A letter report with WLA's detailed interpretations of the stratigraphy of the surficial deposits identified in the two trench segments is provided in Attachment 3. Further details on each trench segment are available in the Soil Sampling Field Forms for Trench Samples (Appendix B).

Trenching Area 1: Located in Geophysical Area 1, this trenching area was selected to investigate the vicinity of one of the HEST tests conducted in 1967 (Table 2.1). The first trench segment excavated in this area was oriented in an east-west (E-W) direction. The E-W trench (samples 0001-0020) was excavated to a depth of 12 feet (the limit of the backhoe) and never encountered undisturbed soils. The trench appeared to have been located over a large test debris burial area, possibly in an area where the Norwegian Aircraft Shelter test debris was buried. In the shallow portion of the trench (0 to 3 feet below ground surface), small quantities of wood, plastic, and rock debris were encountered. In the deeper portions of the trench (3 feet to 12 feet below ground surface), large quantities of wood and cement with rebar reinforcement were encountered. The eastern-most portion of the trench encountered what appeared to be a cement wall at 3 feet below ground surface. The cement wall was too large to be moved, so the trench was extended 3 feet to the west. The cement wall may have been buried in the debris-filled trench identified by the geophysical surveys. However, it appears that the entire area around the E-W trench was used for debris burial and disposal.

Upon completion of the E-W trench segment, the north-south (N-S) trench segment (samples 0021-0040) was excavated in an area originally thought to be just west of the debris-filled trench identified by the geophysical surveys. However, the N-S trench encountered similar wood debris and reinforced concrete walls as encountered in the E-W trench. The debris in the N-S trench could not be removed by the backhoe, and the trench was stopped at 6 feet below ground surface when undisturbed calcium carbonate horizon was encountered under one corner of a large

cement wall. The presence of the undisturbed calcum carbonate horizon (caliche) is important because it requires at least several tens of thousands of years to form and is an indicator of relative surface stability (Attachment 3). Thick caliche layers show an absence of cultural modification at the depths of the horizon. Because undisturbed soils were encountered at 6 feet below ground surface, it was believed that the N-S trench was on the edge of the large debris disposal area.

Native soils were overlain by soil fill containing test debris. The soil fill material excavated from each trench segment was a moderately-sorted, clayey, silty sand that contained occassional pebbles, cobbles, or boulders. The similarity of the fill material with native soils indicates the fill was probably from an on-site location. The soil fill was light-brown, and some carbonate-cemented grains were visible. The carbonate-cemented grains in the disturbed material were blocky and broken, indicating that the cemented materials had been previously disturbed. The caliche layer identified in the southern corner of the N-S trench was a silty sand with carbonate cementation between the grains. The soil in the caliche layer was whitish-brown. A thin surface soil horizon was present over the entire trenching area. WL&A, Inc. interpreted the upper 5-feet within the trench to be fine-grained eolian loess (wind-blown deposits) covering fine eolian fine gravel deposits of unknown thickness. The boundary at the base of the caliche horizon appears to be controlled by the stratigraphic contact between fine-grained eolian loess and underlying gravel.

<u>Trenching Area 2</u>: This trenching area was selected to investigate a subsurface ferrous metal geophysical anomaly that was possibly associated with a HEST test (Figure 2.2). The first trench segment excavated in this area was oriented in a N-S direction (samples 0041-0060), with trenching proceeding from south to north toward an area of buried debris identified from the geophysical surveys. Burned steel cable and rebar debris encountered in the first 3-foot lift on the south side of the trench could not be removed, and the trench segment was subsequently moved 5 feet further north. The N-S trench segment was excavated to a total depth of nine feet below ground surface, with native soils encountered between approximately 7 feet below ground surface. The top 3 feet of the trench consisted primarily of fill material containing wood, cable, and cable reels. A layer of burned debris (wood, steel cables, spools, and bolts) was encountered between 2 feet and 3 feet below ground surface across the entire trench. A second layer of burned debris was encountered between 4 feet and 5 feet below ground surface, and included larger pieces of burned wood that appeared to be railroad ties. During excavation of the 3- to 6-foot lift, a small (approximately 1 foot long) piece of hollow plastic cord filled with white powder was found. Analysis of the powder in the tube at a local laboratory determined that the

powder was RDX, a common explosive detonator compound. Between the second burned layer and the native soils was a thin layer of fill material containing abundant wood debris. The layers of burned and unburned debris dipped to the south, indicating that the deeper portion of the depression, that was used for debris burning and burial, may be to the south.

Upon completion of the N-S trench segment, the E-W trench segment (samples 0061-0080) was excavated to a depth of 9 feet. As with the N-S trench, abundant burned wood, steel bolts, and rock debris were excavated. Two prominent layers of burned wood were identified at 4 feet and 6 feet below ground surface. Undisturbed soils were encountered at a depth of 6-1/2 feet below ground surface. Overlying disturbed soils was very similar to that found in Trenching Area 1.

A distinct caliche layer was encountered in both trench segments in the area, and consisted of a silty sand with carbonate cementation between the grains. The caliche soil was whitish-brown. The caliche layer was essentially flat in the E-W trench segment, but sloped to the south in the N-S trench segment. Because caliche layers usually parallel the ground surface, the presence of a sloping caliche layer in the N-S trench segment indicates that some of the caliche layer may have been previously excavated or altered in an explosion. A thin surface soil horizon was present over the entire trenching area.

<u>Trenching Area 3</u>: This trenching area was selected to investigate a portion of Geophysical Area 2, where conductive soils were identified during the geophysical surveys and a surface depression was present. The first trench segment excavated in this area had a N-S orientation (samples 0091-0110), and reached a total depth of 9 feet. The soils in the top 3 feet of the trench were interpreted as fill material, because wood chips were present. A caliche layer was present between 5 feet and 6 feet below ground surface. The caliche layer had a rounded shape, sloped to the north, and looked very similar to the shape of the craters on the site. Upon completion of the N-S trench segment, the E-W trench segment (samples 0111-0130) was excavated to a depth of 6 feet. The top 3 feet of the trench was a mix of fill material (including small rock fragments) and native soils. A distinct horizontal caliche layer was then encountered at 3 feet below ground surface. Based on observations during trenching, it was concluded that a crater or depression had been filled in this area.

A thin organic-rich surface soil horizon was present in both trench segments. The fill materials in the upper 3 feet of the trench segments were primarily well-sorted, light-brown, clayey, silty sands, with no indications of carbonate cement. The native soils, when present above the caliche horizons, contained more clay than the fill materials. Within the caliche layer, a variety of soil

types were encountered. The two primary soil types identified in the caliche layer were a well-sorted whitish-brown clayey silty sand, and a whitish-brown wet silty clay. Interbedded throughout the caliche layer was a light-brown clayey silty sand. Throughout the caliche layer, but very abundant at its base, were larger grain sizes such as cobbles and pebbles. The grain size distribution in the lower part of the caliche layer indicated a depositional environment such as alluvial system. The well-sorted silty sands identified between the upper caliche layer and the ground surface were more indicative of an eolian environment. The clay-rich soils also identified above the caliche layer were consistent with a playa setting.

Trenching Area 4: This trenching area was selected to investigate a portion of Geophysical Area 4, where geophysical surveys identified a large anomaly and the ground surface had been extensively disturbed. The first trench segment excavated was in a N-S orientation (samples 0166-0185), and was excavated to a total depth of six feet. Four bundles of ¼-inch diameter cable (a total of 88 strands of cable) running perpendicular to the trench were unearthed along with a few rock fragments in the first 3 feet below ground surface. An undisturbed caliche layer was encountered at 3 feet below ground surface in the N-S trench segment.

After completing the N-S trench segment, the E-W trench segment (samples 0186-0205) was excavated to a depth of 6 feet. Two bundles of ¼-inch diameter cable (a total of 55 strands of cable) were encountered running parallel to the length of the trench at 6 inches and at 2 feet below ground surface. A small area of fill was found on the western side of the trench. The upper 6 inches of the trench segments consisted of an organic-rich soil horizon. The fill materials in the upper 2 feet to 3 feet of the trenches were primarily well-sorted light-brown, clayey, silty sands, with a few carbonate-cemented grains.

Caliche-rich soils were encountered at approximately 2 feet below ground surface. Within the caliche layer, the primary soil type identified was a well-sorted whitish-brown, clayey, silty sand. Interbedded throughout the caliche layer was a light-brown, clayey, silty, sand. Throughout the caliche layer, but very abundant at its base, were larger grain sizes such as cobbles and pebbles. The grain size distribution in the lower part of the caliche layer indicated a depositional environment such as an alluvial system. The well-sorted, silty sands from the upper caliche layer to the ground surface were more indicative of an eolian environment.

4.2.2 Soils at Hand Auger Locations

The soils investigated at the hand-auger locations are essentially the same as those encountered during trenching activities. The upper 6 inches of the soil profile included a brown, organic-rich, clayey, silty sand. The most abundant soils above the carbonate-cemented caliche layer (which was usually encountered between 3 and 5 feet below ground surface) were light-brown, clayey, silty sands, and light-brown, clayey sands. The soils had some carbonate-cemented inclusions, which became more abundant moving down in the soil profile toward the caliche layer. The caliche layer consisted of two primary soil types: a well-sorted, whitish-brown, clayey, silty sand, and a whitish-brown wet silty clay. Interbeds of light-brown, clayey, silty sand and light-brown, silty, gravelly, sand were often found in the caliche layers. Throughout the caliche layer, but very abundant at its base, were larger grain sizes such as cobbles and pebbles. The grain size distribution in the lower part of the caliche layer indicates a higher energy depositional environment such as an alluvial system. The well-sorted silty sands above the caliche layer were more indicative of an eolian environment. The clay-rich soils encountered above the caliche layer at several sampling areas in the southern portion of the site were consistent with a playa setting. Test debris encountered during hand-augering was limited, and consisted mostly of cement and instrument wiring. Further details on each hand-auger sampling location are available in the Soil Sampling Field Forms for Hand Auger Samples (Appendix C).

4.3 Surface Water Sampling

Because there was minimal precipitation during the field sampling program, insufficient ponding occurred to allow surface water sampling on-site. Attempts were made to collect surface water samples immediately after two precipitation events, but the infiltration of the water into the soils was too rapid. One surface water sample was collected, but it was from a background location approximately two miles east of the site. Ponding was present on-site within the playa area, but the water had been ponded for a long time (as evidenced by algae on its surface) and it was decided that the existing ponds were not acceptable sampling locations.

5.0 ANALYTICAL RESULTS

Summaries of the field screening analytical results for nitrates, TNT, PETN and SVOCs are presented in Table 5.1. Field screening results for radioactivity are presented in Table 5.2. Copies of the field screening worksheets and the laboratory logbook pages are presented in Appendix F. Quanterra Environmental Services of Sacramento, California was contracted to perform laboratory analyses for explosives, metals, SVOCs, and nitrates. Armstrong Laboratory of Brooks Air Force Base, Texas, performed radiological analyses through the direction of Phillips Laboratory.

5.1 Field Screening Analytical Results

The purpose of the field screening activity was to optimize the use of laboratory analyses by pre-screening all soil samples and near-surface soil samples (hand-auger samples) in the field, and where feasible, selecting those samples showing evidence of contamination for laboratory analysis. A total of 300 samples were screened for TNT and nitrates, 305 samples were screened for SVOCs and PETN, and 310 samples were screened for radioactivity. Field screening results were used as a guide for determining which soil samples would be submitted to Quanterra and Armstrong Laboratory for analysis. Based on the results of the field screening activities, soil samples from 40 sampling locations were submitted to Quanterra Environmental Services and analyzed for explosives, nitrate+nitrite, metals, and cyanide; and soil samples from 20 sampling locations were sent for SVOC analysis. Additional composite samples from the 17 trenching and hand-augering sampling areas were submitted to Armstrong Laboratory and analyzed for gross alpha, gross beta and specific radionuclides by gamma spectrometry. A comparison of field screening and laboratory analytical results for the soil samples is presented in Table 5.3.

5.1.1 Nitrate Field Screening Results

Concentrations of nitrate were detected in approximately 245 of the soil samples screened. Concentrations above the detection limit (1 ppm) ranged from 1 ppm to greater than 50 ppm (Table 5.1). Of the 40 samples submitted to Quanterra for quantitative analysis, the concentrations of nitrate detected in the samples were reproducible to those detected during the field screening activities. The relative percent difference (RPD) between the field screening results and the laboratory results averaged approximately 40%. A comparison of the field screening results and the laboratory analytical results obtained from Quanterra Environmental Services is presented in Table 5.3.

Table 5.1 Summary of Field Screening Analytical Results

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0001	16	09/15/94	11	ND	-
KRLTD154-0002	16	09/15/94	3	ND	-
KRLTD154-0003	16	09/15/94	7	ND	-
KRLTD154-0004	16	09/15/94	4	ND	-
KRLTD154-0005	16	09/15/94	4	ND	-
KRLTD154-0006	16	09/15/94	5	ND	-
KRLTD154-0007	16	09/15/94	6	ND	-
KRLTD154-0008	16	09/15/94	5	ND	-
KRLTD154-0009	16	09/15/94	4	ND	-
KRLTD154-0010	16	09/15/94	5	ND	-
KRLTD154-0011	16	09/15/94	5	ND	-
KRLTD154-0012	16	09/15/94	3	ND	-
KRLTD154-0013	16	09/15/94	5	ND	-
KRLTD154-0014	16	09/15/94	5	ND	-
KRLTD154-0015	16	09/15/94	4	ND	-
KRLTD154-0016	16	09/15/94	ND	ND	-
KRLTD154-0017	16	09/15/94	3	ND	-
KRLTD154-0018	16	09/15/94	5	ND	-
KRLTD154-0019	16	09/15/94	ND	ND	-
KRLTD154-0020	16	09/15/94	3	ND	-
KRLTD154-0020 DUP.	16	09/15/94	3	ND	-
KRLTD154-0021	16	09/15/94	3	ND	-
KRLTD154-0022	16	09/15/94	1	ND	-
KRLTD154-0023	16	09/15/94	2	ND	-
KRLTD154-0024	16	09/15/94	3	ND	-
KRLTD154-0025	16	09/15/94	ND	ND	-
KRLTD154-0026	16	09/15/94	3	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0027	16	09/15/94	5	ND	-
KRLTD154-0028	16	09/15/94	5	ND	-
KRLTD154-0029	16	09/15/94	ND	ND	-
KRLTD154-0030	16	09/15/94	4	ND	-
KRLTD154-0031	17	09/16/94	3	ND	-
KRLTD154-0032	17	09/16/94	3	ND	-
KRLTD154-0033	17	09/16/94	8	ND	-
KRLTD154-0034	17	09/16/94	9	ND	-
KRLTD154-0035	17	09/16/94	7	ND	-
KRLTD154-0036	17	09/16/94	7	ND	-
KRLTD154-0037	17	09/16/94	4	ND	-
KRLTD154-0038	17	09/16/94	ND	ND	-
KRLTD154-0039	17	09/16/94	ND	ND	-
KRLTD154-0040	17	09/16/94	ND	ND	-
KRLTD154-0040 DUP.	17	09/16/94	ND	ND	-
KRLTD154-0041	14	09/13/94	ND	ND	+
KRLTD154-0042	14	09/13/94	2	ND	-
KRLTD154-0043	14	09/13/94	1	ND	+
KRLTD154-0044	14	09/13/94	4	ND	-
KRLTD154-0045	14	09/13/94	2	ND	-
KRLTD154-0046	14	09/13/94	4	ND	+
KRLTD154-0047	14	09/13/94	15	ND	-
KRLTD154-0048	14	09/13/94	8	ND	+
KRLTD154-0049	14	09/13/94	3	ND	+
KRLTD154-0050	14	09/13/94	3	ND	-
KRLTD154-0051	14	09/13/94	9	ND	-
KRLTD154-0052	14	09/13/94	3	ND	-
KRLTD154-0053	14	09/13/94	8	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0054	14	09/13/94	3	ND	-
KRLTD154-0055	14	09/13/94	3	ND	-
KRLTD154-0056	14	09/13/94	1	ND	+
KRLTD154-0057	14	09/13/94	3	ND	+
KRLTD154-0058	14	09/13/94	3	ND	+
KRLTD154-0059	14	09/13/94	2	ND	+
KRLTD154-0060	14	09/13/94	3	ND	+
KRLTD154-0060 DUP.	14	09/13/94	3	ND	+
KRLTD154-0061	15	09/14/94	ND	ND	+
KRLTD154-0062	15	09/14/94	5	ND	-
KRLTD154-0063	15	09/14/94	2	ND	-
KRLTD154-0064	15	09/14/94	ND	ND	-
KRLTD154-0065	15	09/14/94	2	ND	-
KRLTD154-0066	15	09/14/94	18	ND	-
KRLTD154-0067	15	09/14/94	ND	ND	-
KRLTD154-0068	15	09/14/94	5	ND	-
KRLTD154-0069	15	09/14/94	3	ND	-
KRLTD154-0070	15	09/14/94	3	ND	-
KRLTD154-0071	15	09/14/94	6	ND	-
KRLTD154-0072	15	09/14/94	7	ND	-
KRLTD154-0073	15	09/14/94	4	ND	-
KRLTD154-0074	15	09/14/94	ND	ND	-
KRLTD154-0075	15	09/14/94	4	ND	-
KRLTD154-0076	15	09/14/94	6	ND	+
KRLTD154-0077	15	09/14/94	7	ND	-
KRLTD154-0078	15	09/14/94	8	ND	-
KRLTD154-0079	15	09/14/94	1	ND	-
KRLTD154-0080	15	09/14/94	5	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRTLD154-0080 DUP.	15	9/14/94	5	ND	-
KRTLD154-0081	3	8/26/94	3	ND	-
KRTLD154-0082	3	8/26/94	ND	ND	-
KRTLD154-0083	3	8/26/94	3	ND	-
KRTLD154-0084	3	8/26/94	48	ND	-
KRTLD154-0085	3	8/26/94	ND	ND	-
KRTLD154-0086	3	8/26/94	1	ND	-
KRTLD154-0087	3	8/26/94	1	ND	-
KRTLD154-0088	3	8/26/94	ND	ND	-
KRTLD154-0089	3	8/26/94	ND	ND	-
KRTLD154-0090	3	8/26/94	1	ND	-
KRTLD154-0091	12	9/12/94	3	ND	-
KRTLD154-0092	12	9/12/94	8	ND	-
KRTLD154-0093	12	9/12/94	13	ND	-
KRTLD154-0094	12	9/12/94	ND	ND	-
KRTLD154-0095	12	9/12/94	11	ND	-
KRTLD154-0096	12	9/12/94	7	ND	-
KRTLD154-0097	12	9/12/94	8	ND	+
KRTLD154-0098	12	9/12/94	3	ND	-
KRTLD154-0099	12	9/12/94	5	ND	-
KRTLD154-00100	12	9/12/94	3	ND	-
KRTLD154-00100 DUP.	12	9/12/94	4	ND	-
KRTLD154-00101	12	9/12/94	11	ND	-
KRTLD154-00102	12	9/12/94	5	ND	-
KRTLD154-00103	12	9/12/94	ND	ND	-
KRTLD154-00104	12	9/12/94	3	ND	-
KRTLD154-00105	12	9/12/94	3	ND	-
KRTLD154-00106	12	9/12/94	2	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0107	12	09/12/94	5	ND	-
KRLTD154-0108	12	09/12/94	2	ND	-
KRLTD154-0109	12	09/12/94	15	ND	-
KRLTD154-0110	12	09/12/94	5	ND	-
KRLTD154-0111	13	09/13/94	2	ND	-
KRLTD154-0112	13	09/13/94	4	ND	-
KRLTD154-0113	13	09/13/94	7	ND	-
KRLTD154-0114	13	09/13/94	4	ND	-
KRLTD154-0115	13	09/13/94	6	ND	-
KRLTD154-0116	13	09/13/94	4	ND	-
KRLTD154-0117	13	09/13/94	5	ND	-
KRLTD154-0118	13	09/13/94	3	ND	-
KRLTD154-0119	13	09/13/94	6	ND	-
KRLTD154-0120	13	09/13/94	8	ND	-
KRLTD154-0120 DUP.	13	09/13/94	6	ND	-
KRLTD154-0121	13	09/13/94	7	ND	-
KRLTD154-0122	13	09/13/94	5	ND	-
KRLTD154-0123	13	09/13/94	6	ND	-
KRLTD154-0124	13	09/13/94	7	ND	-
KRLTD154-0125	13	09/13/94	5	ND	-
KRLTD154-0126	13	09/13/94	3	ND	-
KRLTD154-0127	13	09/13/94	8	ND	-
KRLTD154-0128	13	09/13/94	1	ND	-
KRLTD154-0129	13	09/13/94	1	ND	-
KRLTD154-0130	13	09/13/94	1	ND	-
KRLTD154-0131	17	09/16/94	2	ND	-
KRLTD154-0132	17	09/16/94	1	ND	-
KRLTD154-0133	17	09/16/94	2	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0134	17	09/16/94	3	ND	-
KRLTD154-0135	17	09/16/94	1	ND	-
KRLTD154-0136	17	09/16/94	ND	ND	-
KRLTD154-0137	17	09/16/94	5	ND	-
KRLTD154-0138	17	09/16/94	1	ND	-
KRLTD154-0139	17	09/16/94	ND	ND	-
KRLTD154-0140	17	09/16/94	4	ND	-
KRLTD154-0140 DUP.	17	09/16/94	4	ND	-
KRLTD154-0141	17	09/16/94	ND	ND	-
KRLTD154-0142	17	09/16/94	2	ND	-
KRLTD154-0143	18	09/19/94	ND	ND	-
KRLTD154-0144	18	09/19/94	2	ND	-
KRLTD154-0145	18	09/19/94	ND	ND	-
KRLTD154-0146	18	09/19/94	3	ND	-
KRLTD154-0147	18	09/19/94	2	ND	-
KRLTD154-0148	18	09/19/94	5	ND	-
KRLTD154-0149	18	09/19/94	2	ND	-
KRLTD154-0150	18	09/19/94	ND	ND	-
KRLTD154-0151	4	08/29/94	4	ND	-
KRLTD154-0152	4	08/29/94	ND	ND	-
KRLTD154-0153	4	08/29/94	2	ND	-
KRLTD154-0154	4	08/29/94	2	ND	-
KRLTD154-0155	4	08/29/94	1	ND	-
KRLTD154-0156	4	08/29/94	2	ND	-
KRLTD154-0157	4	08/29/94	7	ND	-
KRLTD154-0158	4	08/29/94	2	ND	-
KRLTD154-0159	4	08/29/94	2	ND	-
KRLTD154-0160	4	08/29/94	3	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0160 DUP.	4	08/29/94	5	ND	-
KRLTD154-0161	4	08/29/94	5	ND	-
KRLTD154-0162	4	08/29/94	ND	ND	-
KRLTD154-0163	4	08/29/94	2	ND	-
KRLTD154-0164	4	08/29/94	2	ND	-
KRLTD154-0165	4	08/29/94	12	ND	-
KRLTD154-0166	10	09/08/94	1	ND	-
KRLTD154-0167	10	09/08/94	1	ND	-
KRLTD154-0168	10	09/08/94	ND	ND	-
KRLTD154-0169	10	09/08/94	ND	ND	-
KRLTD154-0170	10	09/08/94	ND	ND	-
KRLTD154-0171	10	09/08/94	6	ND	-
KRLTD154-0172	10	09/08/94	9	ND	-
KRLTD154-0173	10	09/08/94	2	ND	-
KRLTD154-0174	10	09/08/94	2	ND	-
KRLTD154-0175	10	09/08/94	6	ND	-
KRLTD154-0176	10	09/08/94	15	ND	-
KRLTD154-0177	10	09/08/94	8	ND	-
KRLTD154-0178	10	09/08/94	9	ND	-
KRLTD154-0179	10	09/08/94	3	ND	-
KRLTD154-0180	10	09/08/94	12	ND	-
KRLTD154-0180 DUP.	10	09/08/94	11	ND	-
KRLTD154-0181	10	09/08/94	6	ND	-
KRLTD154-0182	10	09/08/94	7	ND	-
KRLTD154-0183	10	09/08/94	7	ND	-
KRLTD154-0184	10	09/08/94	7	ND	-
KRLTD154-0185	10	09/08/94	5	ND	-
KRLTD154-0186	11	09/09/94	4	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0187	11	09/09/94	1	ND	-
KRLTD154-0188	11	09/09/94	2	ND	-
KRLTD154-0189	11	09/09/94	1	ND	-
KRLTD154-0190	11	09/09/94	5	ND	-
KRLTD154-0191	11	09/09/94	11	ND	-
KRLTD154-0192	11	09/09/94	4	ND	-
KRLTD154-0193	11	09/09/94	7	ND	+
KRLTD154-0194	11	09/09/94	8	ND	-
KRLTD154-0195	11	09/09/94	8	ND	-
KRLTD154-0196	11	09/09/94	7	ND	-
KRLTD154-0197	11	09/09/94	ND	ND	-
KRLTD154-0198	11	09/09/94	5	ND	-
KRLTD154-0199	11	09/09/94	3	ND	-
KRLTD154-0200	11	09/09/94	1	ND	-
KRLTD154-0200 DUP.	11	09/09/94	1	ND	-
KRLTD154-0201	11	09/09/94	ND	ND	-
KRLTD154-0202	11	09/09/94	4	ND	-
KRLTD154-0203	11	09/09/94	ND	ND	-
KRLTD154-0204	11	09/09/94	2	ND	-
KRLTD154-0205	11	09/09/94	2	ND	-
KRLTD154-0206	18	09/19/94	2	ND	-
KRLTD154-0207	18	09/19/94	ND	ND	-
KRLTD154-0208	18	09/19/94	ND	ND	-
KRLTD154-0209	18	09/19/94	ND	ND	-
KRLTD154-0210	18	09/19/94	ND	ND	-
KRLTD154-0211	18	09/19/94	ND	ND	-
KRLTD154-0212	18	09/19/94	2	ND	-
KRLTD154-0213	18	09/19/94	ND	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0214	19	09/20/94	2	ND	-
KRLTD154-0215	19	09/20/94	ND	ND	-
KRLTD154-0216	19	09/20/94	3	ND	-
KRLTD154-0217	19	09/20/94	2	ND	-
KRLTD154-0218	19	09/20/94	3	ND	-
KRLTD154-0219	19	09/20/94	1	ND	-
KRLTD154-0220	19	09/20/94	ND	ND	-
KRLTD154-0220 DUP.	19	09/20/94	1	ND	-
KRLTD154-0221	19	09/20/94	1	ND	-
KRLTD154-0222	19	09/20/94	ND	ND	-
KRLTD154-0223	19	09/20/94	1	ND	-
KRLTD154-0224	19	09/20/94	ND	ND	-
KRLTD154-0225	19	09/20/94	ND	ND	-
KRLTD154-0226	6	08/31/94	2	ND	-
KRLTD154-0227	6	08/31/94	2	ND	-
KRLTD154-0228	6	08/31/94	ND	ND	-
KRLTD154-0229	6	08/31/94	4	ND	-
KRLTD154-0230	6	08/31/94	ND	ND	-
KRLTD154-0231	6	08/31/94	1	ND	-
KRLTD154-0232	6	08/31/94	ND	ND	-
KRLTD154-0233	6	08/31/94	ND	ND	-
KRLTD154-0234	6	08/31/94	2	ND	-
KRLTD154-0235	6	08/31/94	8	ND	-
KRLTD154-0236	6	08/31/94	5	ND	-
KRLTD154-0237	6	08/31/94	6	ND	-
KRLTD154-0238	7	09/01/94	22	ND	-
KRLTD154-0239	7	09/01/94	2	ND	-
KRLTD154-0240	7	09/01/94	4	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0240 DUP.	7	09/01/94	2	ND	-
KRLTD154-0241	7	09/01/94	4	ND	-
KRLTD154-0242	7	09/01/94	3	ND	-
KRLTD154-0243	7	09/01/94	ND	ND	-
KRLTD154-0244	7	09/01/94	3	ND	-
KRLTD154-0245	7	09/01/94	ND	ND	-
KRLTD154-0246	NA	09/02/94	NA	NA	NA
KRLTD154-0247	NA	09/02/94	NA	NA	NA
KRLTD154-0248	NA	09/02/94	NA	NA	NA
KRLTD154-0249	NA	09/02/94	NA	NA	NA
KRLTD154-0250	NA	09/02/94	NA	NA	NA
KRLTD154-0251	8	09/02/94	3	ND	-
KRLTD154-0252	8	09/02/94	7	ND	-
KRLTD154-0253	8	09/02/94	ND	ND	-
KRLTD154-0254	8	09/02/94	> 50	ND	-
KRLTD154-0255	8	09/02/94	14	ND	-
KRLTD154-0256	8	09/02/94	2	ND	-
KRLTD154-0257	8	09/02/94	ND	ND	-
KRLTD154-0258-0001	8	09/02/94	1	ND	-
KRLTD154-0258-0002	8	09/02/94	2	ND	-
KRLTD154-0259	8	09/02/94	1	ND	-
KRLTD154-0260	8	09/02/94	ND	ND	-
KRLTD154-0260 DUP.	8	09/02/94	ND	ND	-
KRLTD154-0261	8	09/02/94	5	ND	-
KRLTD154-0262	8	09/02/94	5	ND	-
KRLTD154-0263	8	09/02/94	3	ND	-
KRLTD154-0264	8	09/02/94	2	ND	-
KRLTD154-0265	8	09/02/94	3	ND	-

Table 5.1 Summary of Field Screening Analytical Results (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0266	9	09/06/94	13	ND	-
KRLTD154-0267	9	09/06/94	4	ND	-
KRLTD154-0268	9	09/06/94	4	ND	-
KRLTD154-0269	9	09/06/94	3	ND	-
KRLTD154-0270	9	09/06/94	6	ND	-
KRLTD154-0271	NA	08/31/94	NA	NA	-
KRLTD154-0272	NA	08/31/94	NA	NA	-
KRLTD154-0273	NA	08/31/94	NA	NA	-
KRLTD154-0274	NA	08/31/94	NA	NA	-
KRLTD154-0275	NA	08/31/94	NA	NA	-
KRLTD154-0276	1	08/24/94	9	ND	+
KRLTD154-0277	1	08/24/94	4	ND	+
KRLTD154-0278	2	08/25/94	2	ND	-
KRLTD154-0279	2	08/25/94	2	ND	-
KRLTD154-0280	2	08/25/94	1	ND	-
KRLTD154-0280 DUP.	2	08/25/94	NA	NA	-
KRLTD154-0281	2	08/25/94	8	ND	-
KRLTD154-0282	2	08/25/94	2	ND	-
KRLTD154-0283	2	08/25/94	2	ND	-
KRLTD154-0284	3	08/26/94	45	ND	-
KRLTD154-0285	3	08/26/94	ND	ND	-
KRLTD154-0286	7	09/01/94	ND	ND	-
KRLTD154-0287	7	09/01/94	ND	ND	-
KRLTD154-0288	7	09/01/94	2	ND	-
KRLTD154-0289	7	09/01/94	2	ND	-
KRLTD154-0290	7	09/01/94	1	ND	-
KRLTD154-0291	7	09/01/94	2	ND	-
KRLTD154-0292	7	09/01/94	3	ND	-

Table 5.1 Summary of Field Screening Analytical Results (concluded)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN and/or SVOCs
KRLTD154-0293	7	09/01/94	4	ND	-
KRLTD154-0294	7	09/01/94	4	ND	-
KRLTD154-0295	7	09/01/94	6	ND	-
KRLTD154-0296	9	09/06/94	6	ND	-
KRLTD154-0297	9	09/06/94	4	ND	-
KRLTD154-0298	9	09/06/94	1	ND	-
KRLTD154-0299	9	09/06/94	ND	ND	-
KRLTD154-0300	9	09/06/94	2	ND	-
KRLTD154-0300 DUP.	9	09/06/94	ND	ND	-
KRLTD154-0301	5	08/30/94	5	ND	-
KRLTD154-0302	5	08/30/94	3	ND	-
KRLTD154-0303	5	08/30/94	1	ND	-
KRLTD154-0304	5	08/30/94	2	ND	-
KRLTD154-0305	5	08/30/94	1	ND	-
KRLTD154-0306	5	08/30/94	3	ND	-
KRLTD154-0307	5	08/30/94	39	ND	-
KRLTD154-0308	5	08/30/94	4	ND	-
KRLTD154-0309	5	08/30/94	ND	ND	-
KRLTD154-0310	5	08/30/94	3	ND	-
KRLTD154-0310 DUP.	5	08/30/94	3	ND	-

SVOC = Semi-volatile organic compounds
ND = Below method detection limit
NA = Not Analyzed
+ = Hydrocarbons detected
- = No hydrocarbons detected

Table 5.2 Results of Radiological Field Screening

AREA	Alpha (α)	Beta (β) and Gamma (γ)
Geophysical Area 1	< 100 counts per minute	< 45μ R/hr
Geophysical Area 2	< 100 counts per minute	< 45μ R/hr
Geophysical Area 3	< 100 counts per minute	< 45μ R/hr
Geophysical Area 4	< 100 counts per minute	< 45μ R/hr
Geophysical Area 5	< 100 counts per minute	< 45μ R/hr
Gravel Pit	< 100 counts per minute	< 45μ R/hr
DIP 5	< 100 counts per minute	< 45μ R/hr
Generator Site	< 100 counts per minute	< 45μ R/hr
Fuselage Site	< 100 counts per minute	< 45μ R/hr
ART Test	< 100 counts per minute	< 45μ R/hr
Hi Fi Test Bed	< 100 counts per minute	< 45μ R/hr
DCT HEST	< 100 counts per minute	< 45μ R/hr
SSTM Add-on	< 100 counts per minute	< 45μ R/hr
Trenching Area 1	< 100 counts per minute	< 45μ R/hr
Trenching Area 2	< 100 counts per minute	< 45μ R/hr
Trenching Area 3	< 100 counts per minute	< 45μ R/hr
Trenching Area 4	< 100 counts per minute	< 45μ R/hr

Table 5.3 Comparison of Field Screening Results and Laboratory Results

SITE ID NUMBER	FIELD SCREENING	QUANTERRA LABORATORY	FIELD SCREENING		QUANTERRA LABORATORY	
	NITRATES (PPM)	NITRATE + NITRITE (PPM)	TNT (PPM)	PETN and/or SVOCs	EXPLOSIVES (PPM)	SVOCs (PPM)
KRLTD154-0009	4	3.7	ND	-	ND	NA
KRLTD154-0013	5	4.8	ND	-	ND	NA
KRLTD154-0025	ND	1	ND	-	ND	NA
KRLTD154-0035	7	4.9	ND	-	ND	NA
KRLTD154-0046	4	2.5	ND	+	ND	Naphthalene - 58.0 Phenanthrene - 46.0
KRLTD154-0047	15	5.6	ND	-	ND	NA
KRLTD154-0049	3	2.1	ND	+	ND	Naphthalene - 0.058(J) Phenanthrene - 0.046(J)
KRLTD154-0076	7	3.7	ND	+	ND	NA
KRLTD154-0081	3	4	ND	-	ND	ND
KRLTD154-0084	48	95.4	ND	-	ND	ND
KRLTD154-0097	8	8.3	ND	+	ND	ND
KRLTD154-0109	15	1.7	ND	-	ND	ND
KRLTD154-0113	7	5	ND	-	ND	ND
KRLTD154-0120	8	4.1	ND	-	ND	ND

Table 5.3 Comparison of Field Screening Results and Laboratory Results (continued)

SITE ID NUMBER	FIELD SCREENING	QUANTERRA LABORATORY	FIELD SCREENING		QUANTERRA LABORATORY	
	NITRATES (PPM)	NITRATE + NITRITE (PPM)	TNT (PPM)	PETN and/or SVOCs	EXPLOSIVES (PPM)	SVOCs (PPM)
KRLTD154-0136	ND	1.4	ND	-	ND	NA
KRLTD154-0140	4	4	ND	-	ND	ND
KRLTD154-0151	4	2	ND	-	ND	ND
KRLTD154-0157	7	5.4	ND	-	ND	ND
KRLTD154-0160	3	3	ND	-	ND	ND
KRLTD154-0161	5	2.4	ND	-	ND	ND
KRLTD154-0165	12	8.4	ND	-	ND	ND
KRLTD154-0178	9	8.3	ND	-	ND	ND
KRLTD154-0179	3	5.6	ND	-	ND	ND
KRLTD154-0180	12	12.9	ND	-	ND	ND
KRLTD154-0193	7	8.3	ND	+	ND	ND
KRLTD154-0215	ND	1	ND	-	ND	ND
KRLTD154-0225	ND	0.58	ND	-	ND	NA
KRLTD154-0231	1	5.5	ND	+	ND	ND
KRLTD154-0238	22	23.1	ND	-	ND	ND
KRLTD154-0254	> 50	386	ND	-	ND	ND
KRLTD154-0255	14	9.9	ND	-	ND	ND

Table 5.3 Comparison of Field Screening Results and Laboratory Results (concluded)

SITE ID NUMBER	FIELD SCREENING	QUANTERRA LABORATORY	FIELD SCREENING		QUANTERRA LABORATORY	
	NITRATES (PPM)	NITRATE + NITRITE (PPM)	TNT (PPM)	PETN and/or SVOCs	EXPLOSIVES (PPM)	SVOCs (PPM)
KRLTD154-0258-0 001	1	1.3	ND	-	ND	ND
KRLTD154-0266	13	10.9	ND	-	ND	Diethyl phthalate - 0.80
KRLTD154-0276	9	8.4	ND	+	ND	ND
KRLTD154-0284	45	68.6	ND	-	ND	ND
KRLTD154-0288	2	2.6	ND	-	ND	NA
KRLTD154-0292	3	3.8	ND	-	ND	ND
KRLTD154-0296	6	6.5	ND	-	ND	ND
KRLTD154-0301	5	2.3	ND	-	ND	ND
KRLTD154-0307	39	46.8	ND	-	ND	ND

NA = Not Analyzed

ND = Below Method Detection Limit

- = Hydrocarbons Not Detected

+ = Hydrocarbons Detected

J = Value between MDL and PQL

5.1.2 TNT Field Screening Results

The Ensys TNT soil test method has been demonstrated to correctly identify 95% of samples containing 1 ppm or greater of TNT (Ensys, Inc., 1993) and is capable of detecting TNT at concentrations greater than or equal to 0.7 ppm. TNT was not detected in any of the 300 soil samples screened (Table 5.1). Of the 40 samples submitted to Quanterra Environmental Services for further verification of TNT concentrations, all were below detection limits for TNT and associated by-products and degradation products. A comparison of the field screening results and the results obtained from Quanterra Environmental Services is presented in Table 5.3.

5.1.3 PETN and Semi-Volatile Organic Compound Field Screening Results

The TLC procedure for PETN and SVOCs was performed using PETN and diesel standards, to allow direct comparison between the sample results and a positive PETN and SVOC results. A total of 305 samples was screened for PETN and SVOCs using the TLC method. Of these 305 samples, 27 samples showed positive indications that hydrocarbons (e.g., PETN and/or SVOCs) were present in the samples (Table 5.1). No explosives (e.g. PETN) were detected in the samples submitted to Quanterra Environmental for analysis. However, small concentrations of SVOCs were detected in three samples submitted to Quanterra Environmental (Table 5.3).

5.1.4 Radiation Field Screening Results

Results of the field screening identified no alpha, beta, or gamma radiation above action levels in the samples collected (Table 5.2). A comparison of field screening and laboratory analysis for gross alpha, gross beta and gamma spectrometry was not made because the laboratory and field screening methods are not comparable.

5.1.5 QA/QC Samples

Table 3.2 lists the QC samples required, and the sample frequency necessary for each field screening method. Based upon Section 13.0 of the Final Quality Assurance Project Plan (GRAM 1994f), QC samples (i.e., duplicate samples, laboratory blank samples and matrix samples) were used to evaluate data for precision, accuracy, completeness, representativeness and comparability

where applicable. Analytical results of those QC standards analyzed during the field screening activities can be found in Attachment 2.

Field screening QC samples included the following:

- Duplicate Samples
- Matrix Spike Samples
- Method Blank Samples
- Soil Blank Samples
- Blank Spike Samples.

All field QC samples were within the control limits specified in the Final Quality Assurance Project Plan (GRAM, 1994f), for field screening method documentation. Detailed information of the field screening QC results are presented in Attachment 2.

5.2 Laboratory Analytical Results

Table 5.4 identifies the soil samples from the trenching and hand-augering locations that were selected for laboratory analysis. Table 5.5 summarizes the laboratory analytical results for soil samples. Table 5.6 contains results of laboratory analyses on water samples. Table 5.7 presents a summary of radiological analytical results. Results of laboratory analyses were reported as quantitative (without a qualifier) when the concentration was greater than the practical quantitation limit (PQL) of each analytical method. The PQL is the lowest level at which an analyte can be quantified reliably and within the precision and accuracy of the laboratory instrument. However, the laboratory was instructed to report all results above the Method Detection Limit (MDL), which is the minimum concentration at which a substance can be detected with a 99% confidence that the analyte is present. When a substance was found to be at a concentration above the MDL but below the PQL, it was reported with a "J" qualifier. The laboratory PQLs for each constituent analyzed are presented in Appendix A of the Quality Assurance Project Plan for the field program (GRAM, 1994f). The MDLs are constituent- and analysis-specific, and were empirically derived by using guidance from 40 CFR 136, Appendix B.

Table 5.4 Summary of Samples Selected for Laboratory Analysis

SAMPLING AREA	LOCATION ID NUMBER	SAMPLE ID NUMBER	DATE SAMPLED	TIME SAMPLED	FIELD SCREENING RESULTS			LAB ANALYSES SELECTED				
					NITRATES (PPM)	TNT (PPM)	HYDROCARBONS/ PETN	EXPLOSIVES	NO3/NO2	SVOCs	METALS	CYANIDE
Trenching Area 1	0009	0001	9/14/94	0930	4	ND	-	X	X		X	X
	0013	0001	9/14/94	1005	5	ND	-	X	X		X	X
	0025	0001	9/14/94	1245	ND	ND	-	X	X		X	X
	0035	0001	9/14/94	1400	7	ND	-	X	X		X	X
Trenching Area 2	0046	0001	9/12/94	1310	4	ND	+	X	X	X	X	X
	0047	0001	9/12/94	1310	15	ND	-	X	X		X	X
	0047	0002 (DUPLICATE)	9/12/94	1310	15	ND	-	X	X		X	X
	0049	0001	9/12/94	1310	3	ND	+	X	X	X	X	X
	0076	0001	9/13/94	1345	6	ND	+	X	X		X	X
Geophysical Area 1	0081	0001	8/25/94	1030	3	ND	-	X	X		X	X
	0084	0001	8/25/94	1207	48	ND	-	X	X		X	X
	0084	0002 (DUPLICATE)	8/25/94	1207	48	ND	-	X	X		X	X
Trenching Area 3	0097	0001	9/9/94	0900	8	ND	+	X	X	X	X	X
	0109	0001	9/9/94	1030	15	ND	-	X	X		X	X
	0113	0001	9/12/94	0845	7	ND	-	X	X		X	X
	0120	0001	9/12/94	0915	8,6	ND	-	X	X		X	X
Geophysical Area 2	0136	0001	9/15/94	1051	ND	ND	-	X	X		X	X
	0140	0001	9/15/94	1201	4,4	ND	-	X	X	*	X	X
Geophysical Area 3	0151	0001	8/26/94	0900	4	ND	-	X	X			X
	0157	0001	8/26/94	1100	7	ND	-	X	X	X		X
	0160	0001	8/26/94	1213	3,5	ND	-	X	X			X
	0161	0001	8/26/94	1235	5	ND	-	X	X			X
	0165	0001	8/26/94	1340	12	ND	-	X	X	X		X

Table 5.4 Summary of Samples Selected for Laboratory Analysis (continued)

SAMPLING AREA	LOCATION ID NUMBER	SAMPLE ID NUMBER	DATE SAMPLED	TIME SAMPLED	FIELD SCREENING RESULTS			LAB ANALYSES SELECTED				
					NITRATES (PPM)	TNT (PPM)	HYDROCARBONS/ PETN	EXPLOSIVES	NO3/NO2	SVOCs	METALS	CYANIDE
Trenching Area 4	0166	1001 (EQUIPMENT)	9/7/94	1030	NA	NA	NA	X	X	X	X	X
	0178	0001	9/7/94	1500	9	ND	-	X	X		X	X
	0179	0001	9/7/94	1500	3	ND	-	X	X	X	X	X
	0179	0002 (DUPLICATE)	9/7/94	1500	3	ND	-	X	X	X	X	X
	0180	0001	9/7/94	1500	12,11	ND	-	X	X		X	X
	0193	0001	9/8/94	0930	7	ND	+	X	X	X	X	X
Geophysical Area 4	0215	0001	9/19/94	0815	ND	ND	-	X	X	*	X	X
	0225	0001	9/19/94	1030	ND	ND	-	X	X		X	X
Geophysical Area 5	0231	0001	8/30/94	1254	1	ND	-	X	X	X	X	X
	0231	0002 (DUPLICATE)	8/30/94	1254	1	ND	-	X	X	X	X	X
	0238	0001	8/31/94	0845	22	ND	-	X	X	X	X	X
Gravel Pit	0246	0001	9/2/94	0827	NA	NA	NA				X	
	0246	1001 (EQUIPMENT)	9/7/94	1030	NA	NA	NA	X	X	X	X	X
	0246	2001 (AMBIENT)	9/7/94	1030	NA	NA	NA	X	X	X	X	X
	0247	0001	9/2/94	0825	NA	NA	NA				X	
	0247	1001 (EQUIPMENT)	9/7/94	1030	NA	NA	NA	X	X	X	X	X
	0248	0001	9/2/94	0845	NA	NA	NA				X	
	0247	1001 (EQUIPMENT)	9/7/94	1030	NA	NA	NA	X	X	X	X	X
	0249	0001	9/2/94	0910	NA	NA	NA				X	
	0250	0001	9/2/94	0909	NA	NA	NA				X	
Dip 5	0254	0001	9/1/94	0930	>50	ND	-	X	X	X	X	X
	0254	0001 (MS/MSD)	9/1/94	0930	>50	ND	-	X	X	X	X	X

Table 5.4 Summary of Samples Selected for Laboratory Analysis (concluded)

SAMPLING AREA	LOCATION ID NUMBER	SAMPLE ID NUMBER	DATE SAMPLED	TIME SAMPLED	FIELD SCREENING RESULTS			LAB ANALYSES SELECTED				
					NITRATES (PPM)	TNT (PPM)	HYDROCARBONS/ PETN	EXPLOSIVES	NO3/NO2	SVOCs	METALS	CYANIDE
Dip 5 (continued)	0255	0001	9/1/94	1022	14	ND	-	X	X	X	X	X
	0258	0001	9/1/94	1035	1,2	ND	-	X	X	X	X	X
Generator Site	0266	0001	9/9/94	1123	NA	NA	NA	X	X	X	X	X
Fuselage	0271	0001	8/30/94	0939	NA	NA	-			X		
	0273	0001	8/30/94	1004	NA	NA	-			X		
Art Test	0276	0001	8/24/94	0915	9	ND	-	X	X		X	X
	0284	0001	8/25/94	0820	45	ND	-	X	X		X	X
	0284	0001 (MS/MSD)	8/25/94	0820	45	ND	-	X	X		X	X
Hi Fi Test Bed A	0288	0001	8/31/94	1200	2	ND	-	X	X		X	X
	0292	0001	8/31/94	1325	3	ND	-	X	X	X	X	X
DCT Hest	0296	0001	9/9/94	1138	NA	NA	NA	X	X	X	X	X
SSTM Add-On	0301	0001	8/29/94	0851	5	ND	-	X	X		X	X
	0307	0001	8/29/94	1027	39	ND	-	X	X	X	X	X
Background	0311	0001	10/12/94	0945	NA	NA	NA		X		X	
	0312	0001	10/12/94	1010	NA	NA	NA		X		X	

ND Below detection limit of method.
- Hydrocarbons not detected.
+ Hydrocarbons detected.
NA Sample not analyzed for constituent.
* Samples 0140-0001 & 0215-0001 collected for a full suite of analytes were not analyzed for SVOCs due to a laboratory data entry error.
MS\MSD Matrix Spike/Matrix Spike Duplicate
X Sample analyzed.

Table 5.5 Summary of Analytical Laboratory Results, Soil Samples Quanterra Environmental Services

Analyte (mg/kg)	Trenching Area 1				Trenching Area 2					Geophysical Area 1			Trenching Area 3		
	0009-0001	0013-0001	0025-0001	0035-0001	0046-0001	0047-0001	0047-0002 (Duplicate)	0049-0001	0076-0001	0081-0001	0084-0001	0084-0002 (Duplicate)	0097-0001	0109-0001	0113-0001
Explosives	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Semivolatile Organics	-	-	-	-	(1)	-	-	(2)	-	ND	ND	ND	ND	ND	ND
Aluminum	12300	10500	12800	11200	11000	11600	8710	12800	10000	15400	11700	12900	11500	12600	9160
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	5.2	4.2	5.3	4.1	5.9	7.2	5.5	3.7	4	5	4.6	4.4	2.9	2.6	2.1
Barium	139	140	155	169	134	130	115	163	122	151	125	131	135	142	176
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	32900	36500	34100	34300	18300	14300	14500	27100	35600	41300	43700	44500	25700	20200	26400
Chromium	11	9.8	11.2	10.4	14.2	19.5	17.3	11.5	9.2	14.3	10.5	11.4	10.7	17.4	9
Cobalt	ND	ND	5.9	ND	5.7	7.1	6.7	ND	ND	ND	ND	ND	ND	ND	ND
Copper	9	7.6	10	10	191	208	1520	22.8	11.3	8.2	6.5	6.5	6.7	6.8	ND
Iron	12000	10900	12400	11500	27600	30300	27300	12100	10500	12800	10900	11500	10400 (B)	10400 (B)	8600 (B)
Lead	10.2	7.1	10	11.3	27.2	20.4	20.5	25.1	8.3	11.2	8.6	8.2	5.8	5.5	3.7
Magnesium	4380	4030	4520	4380	3660	3880	3280	4160	3700	4470	3790	4040	3510	3450	3010
Manganese	266	242	265	272	408	445	420	257	214	241	190	200	162	172	120
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	19.3	17.1	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	3100	2060	3240	3510	2930	3210	2530	3080	2240	3130	2010	2240	2020	1900	1580
Selenium	0.88	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	19.1	19.5	19.4	16.9	18.1	17.1	15.2	19	17.8	24.7	20.9	22.9	21.3	20.6	18
Zinc	33.4	28.6	34.9	34.5	126	107	100	63.7	41.9	36.1	29	30.3	23.7	24.3	19.4
Cyanide, Total	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate + Nitrite (as N)	3.7	4.8	1	4.9	2.5	5.6	6.3	2.1	3.7	4	95.4	87.4	8.3	1.7	5

Table 5.5 Summary of Laboratory Analytical Results, Soil Samples Quanterra Environmental Services (continued)

Analyte	Trenching Area 3	Geophysical Area 2		Geophysical Area 3					Trenching Area 4					Geophysical Area 4	
	0120-0001	0136-0001	0140-0001	0151-0001	0157-0001	0160-0001	0161-0001	0165-0001	0178-0001	0179-0001	0179-0002 (Duplicate)	0180-0001	0193-0001	0215-0001	0225-0001
Explosives	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Semivolatile Organics	ND	-	X	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	X	-
Aluminum	13400	6760	8010	-	-	-	-	-	7500	10700	9090	8740	10600	5280	7500
Antimony	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Arsenic	3.1	2.3	4.3	-	-	-	-	-	3.3	2.5	2.6	2.9	2.8	2.5	3.1
Barium	237	99.9	135	-	-	-	-	-	130	113	107	98.7	102	117	95.2
Beryllium	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Calcium	37500	30600	34900	-	-	-	-	-	69000	31000	27000	39800	30400	57100	21200
Chromium	12.1	6	7.6	-	-	-	-	-	6.3	8.6	7.9	6.7	8.2	ND	8
Cobalt	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Copper	8	5.3	ND	-	-	-	-	-	ND	6.4	6.5	ND	6.3	ND	6.1
Iron	12000 (B)	6660	8010	-	-	-	-	-	6590 (B)	9300 (B)	8580 (B)	7220 (B)	8690 (B)	5370	7710
Lead	6.4	4.7	5.8	-	-	-	-	-	4.7	6.3	6.3	4.1	4.8	3.3	4.9
Magnesium	4710	2510	2900	-	-	-	-	-	2950	3030	2750	2460	2810	2080	2490
Manganese	198	109	143	-	-	-	-	-	81.9	134	126	77.5	108	71.1	136
Mercury	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Potassium	2100	1370	1840	-	-	-	-	-	1000	1970	1700	1250	1640	913	1690
Selenium	0.73	ND	ND	-	-	-	-	-	0.7	ND	ND	0.51	0.61	ND	ND
Silver	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Sodium	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	ND	ND	ND
Vanadium	24	11.1	14.9	-	-	-	-	-	16	17.1	15.2	15.5	17.8	ND	11.9
Zinc	27.7	18.2	22.1	-	-	-	-	-	15.5	23.2	21.6	16.6	22	13.6	21.2
Cyanide, Total	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate + Nitrite (as N)	4.1	1.4	4	2	5.4	3	2.4	8.4	8.3	5.6	3.5	12.9	8.3	1	0.58

Table 5.5 Summary of Laboratory Analytical Results, Soil Samples Quanterra Environmental Services (continued)

Analyte	Geophysical Area 5			Gravel Pit					Dip 5			Generator Site	Fuselage		Art Test	
	0231-0001	0231-0002 (Duplicate)	0238-0001	0246-0001	0247-0001	0248-0001	0249-0001	0250-0001	0254-0001	0255-0001	0258-0001	0266-0001	0271-0001	0273-0001	0276-0001	0284-0001
Explosives	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	-	-	ND	ND
Semivolatile Organics	ND	ND	ND	-	-	-	-	-	ND	ND	ND	(3)	ND	ND	ND	ND
Aluminum	8970	8280	9970	5490	9800	9100	5240	8170	4910	7270	12500	7840	-	-	6960	8130
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Arsenic	2.5	2.5	3	2.8	2.6	2.8	1.6	1.4	3.1	2.2	2.2	3.2	-	-	3.3	3.4
Barium	163	142	152	154	136	145	104	111	275	111	118	213	-	-	101	162
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Calcium	48000	42100	47100	90700	27300	35400	33000	18100	142000	39900	24000	133000	-	-	59200	62900
Chromium	9.2	8.3	9.9	ND	9.8	8.8	6.6	8.5	5.6	7.7	7.9	9.8	-	-	6.8	7.8
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Copper	7.4	7.2	8.6	5.7	9.2	7.5	ND	8.3	ND	6.4	7.9	ND	-	-	ND	ND
Iron	9150	8620	9720	5550	10300	9230	6070	8700	4420	7300	8640	6930 (B)	-	-	6600	7240
Lead	6.8	6.9	8.4	4.3	9.4	7.3	5.7	5.8	3.4	5.5	6.7	3.5	-	-	4.5	5.4
Magnesium	3860	3640	4090	3010	4030	3790	2750	3610	3490	2980	3050	4400	-	-	2190	2730
Manganese	195	192	220	96.6	231	196	132	215	105	145	184	179	-	-	82.4	104
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Potassium	2600	2390	2910	1210	2810	2590	1450	2820	931	1940	2290	1360	-	-	1290	1690
Selenium	ND	0.69	1.2	ND	2	ND	ND	ND	ND	ND	1.1	0.87	-	-	0.61	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Sodium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	ND	ND
Vanadium	15.6	15.2	15.7	12.2	16.4	15.1	13.9	13.5	12.1	12.2	13.3	16.2	-	-	14.6	15.9
Zinc	26.2	26.1	29.2	14.9	31.1	28.1	17.4	38.3	10.9	20.1	26.1	32.4	-	-	17.2	20.3
Cyanide, Total	ND	ND	ND	-	-	-	-	-	ND	ND	ND	ND	-	-	ND	ND
Nitrate + Nitrite (as N)	5.5	5.4	23.1	-	-	-	-	-	386	9.9	1.3	10.9	-	-	8.4	68.6

Table 5.5 Summary of Laboratory Analytical Results, Soil Samples Quanterra Environmental Services (continued)

Analyte	HI FI Test Bed A		DCT Hest	SSTM Add-On		Background Soils	
	0288-0001	0292-0001	0296-0001	0301-0001	0307-0001	0311-0001	0312-0001
Explosives	ND	ND	ND	ND	ND	-	-
Semivolatile Organics	-	ND	ND	ND	ND	-	-
Aluminum	5800	5840	8650	8030	8520	7940	6120
Antimony	ND	ND	ND	ND	ND	ND	ND
Arsenic	3.2	2.2	2.3	2.5	2.7	2.2	2.2
Barium	187	182	95.4	125	194	127	128
Beryllium	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND
Calcium	137000	87400	22800	24000	41400	53100	58100
Chromium	6.6	6.8	7.8	8.4	8.7	8.5	6
Cobalt	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	6.3	6.2	5.6	ND
Iron	5280	5730	8150 (B)	8330	8730	8210	6230
Lead	3.8	3.3	4.8	6.2	6.3	4	2.9
Magnesium	4300	3740	2450	2910	3440	3310	2730
Manganese	153	94.8	109	154	168	116	71.8
Mercury	ND	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND
Potassium	1240	1210	1440	1630	1610	1450	864
Selenium	ND	0.61	ND	ND	0.79	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND
Sodium	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND
Vanadium	14.4	14.1	15	15.2	14.6	17.3	14.7
Zinc	12.4	13.5	19.4	21.3	23.4	18.8	13.6
Cyanide, Total	ND	ND	ND	ND	ND	-	-
Nitrate + Nitrite (as N)	2.6	3.8	6.5	2.3	46.8	-	-

Table 5.5 Summary of Laboratory Analytical Results, Soil Samples Quanterra Environmental Services (Concluded)

Shaded boxes represent the highest concentration detected for each constituent.

ND Non Detect, the concentration of the constituent is below the Method Detection Limit.
B The ICP method blank (22SEP94-TX) was found to have 5.8 mg/kg of Iron present.
J J Value, the concentration of the constituent is between the Practical Quantitation Limit (PQL) and the Method Detection Limit (MDL).
X Sample entered improperly by laboratory. No analysis was conducted.
- Sample not analyzed for constituent.

(1) Napthalene detected at 58 mg/kg. Above Practical Quantitation Limit of .74 mg/kg.
Phenanthrene detected at 46 mg/kg. Above Practical Quantitation Limit of .74 mg/kg.
(2) Napthalene detected at .058 mg/kg. J value below reporting limit of .74 mg/kg.
Phenanthrene detected at .046 mg/kg. J value below reporting limit of .74 mg/kg.
(3) Diethyl phthalate detected at .80 mg/kg. Above Practical Quantitation Limit of .77 mg/kg.

Table 5.6 Summary of Laboratory Analytical Results, Water Samples Quanterra Environmental Services

Analyte*	Blanks					Back-ground
	Equipment				Ambient	
	0166-1001 (Backhoe)	0246-1001 (Auger)	0247-1001 (Scoop)	0248-1001 (Bowl)	0246-2001	0314-0001 (Off-Site)
Explosives	ND	ND	ND	ND	ND	ND
Semivolatile Organics	ND	ND	ND	ND	ND	(1)
Aluminum	ND	ND	ND	ND	ND	0.82
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND	ND
Barium	ND	ND	ND	ND	ND	0.096
Beryllium	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND
Calcium	0.84	ND	ND	ND	ND	18.5
Chromium	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	ND
Iron	0.4	ND	ND	ND	ND	0.4
Lead	ND	ND	ND	ND	ND	ND
Magnesium	ND	ND	ND	ND	ND	2.8
Manganese	ND	ND	ND	ND	ND	0.023
Mercury	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND
Potassium	ND	ND	ND	ND	ND	ND
Selenium	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND
Sodium	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	ND
Cyanide, Total	ND	ND	ND	ND	ND	ND
Nitrate + Nitrite (as N)	ND	ND	ND	ND	ND	0.64

* Analytical results for water samples are presented as follows:

Explosives and SVOCs - ug/L

Selected metals, Cyanide (Total), and Nitrate + Nitrite as (N) - mg/L

(1) Pentachlorophenol detected at 3.4 ug/L. J value below reporting limit of 50 ug/L.

Table 5.7 Summary of Results of Radiological Analyses Armstrong Laboratory

Sampling Area	Sample ID Number	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	AC 228	AM 241	BI 212	BI 214	CO 60	CS 134	CS 137	K 40	PB 212	PB 214	RA 224	RA 226	TH 228	TH 232	TH 234	TL 208	U 235
Soil Samples (pCi/g)																				
Geophysical Area 1	0317-0001	3.8	29.5			0.03	0.50		0.01	0.01	16.10	0.70	0.60	0.60	0.40	1.30	0.70	0.30	0.20	0.07
	0317-0002 (Duplicate)	4.3	28.4			0.03	0.50		0.01	0.01	16.10	0.70	0.60	0.60	0.40	1.90	0.70	0.30	0.20	0.08
Geophysical Area 3	0318-0001	6.2	29.1			0.03	0.50		0.01	0.02	16.50	0.60	0.60	0.60	0.40	1.30	0.60	0.30	0.20	0.08
Geophysical Area 5	0319-0001	4.7	26.3		0.04	0.03	0.60	0.02	0.01	0.03	16.90	0.80	0.60	0.60	0.40	0.20	0.70	0.30	0.20	0.09
Gravel Pit	0320-0001	5.6	26.4	0.60		0.02	0.60		0.01	0.10	15.60	0.70	0.60	0.60	0.40	1.30		0.30	0.20	0.08
Dip 5	0321-0001	3.8	24.6	0.60		0.03	0.50		0.01	0.05	14.20	0.60	0.60	0.60	0.40	1.50	0.60	0.30	0.20	0.07
Generator Site	0322-0001	5.1	21.5	0.50		0.03	0.60		3.00	0.02	13.50	0.50	0.60	0.05	0.40	1.40	0.50	0.30	0.20	0.07
Fuselage	0323-0001	3.5	23.2	0.50		0.03	0.50		0.01	0.02	14.20	0.50	0.50	0.60	0.40	0.90	0.50	0.20	0.20	0.07
	0323-0002 (Duplicate)	3.0	24.2	0.50		0.30	0.50		0.10	0.01	14.50	0.50	0.50	0.50	0.40	1.00	0.50	0.20	0.25	0.07
Art Test	0324-0001	2.2	24.4	0.50		0.03	0.40		0.01	0.01	14.00	0.50	0.40	0.50	0.40	1.40	0.50	0.30	0.20	0.06
	0324-0001 (MS/MSD)	4.1	21.7	0.50		0.03	0.40		0.01	0.01	14.30	0.50	0.50	0.50	0.40	1.40	0.50	0.20	0.20	0.07
Hi Fi Test Bed A	0325-0001	2.7	23.6	0.50		0.04	0.70		0.01	0.02	11.50	0.50	0.80	0.60	0.40	1.40	0.50	0.40	0.10	0.10
DCT Hest	0326-0001	3.9	22.8	0.60		0.40	0.40		0.02	0.02	14.30	0.60	0.50	0.70	0.50	1.40	0.60	0.30	0.20	0.06
SSTM Add-On	0327-0001	5.0	26.3	0.60		0.40	0.50		0.02	0.02	14.80	0.70	0.60	0.70	0.50	1.50	0.60	0.20	0.20	0.07
Trenching Area 4	0328-0001	3.9	20.6	0.50		0.40	0.40		0.02	0.02	12.90	0.50	0.40	0.60	0.40	1.10	0.50	0.10	0.20	0.05
Trenching Area 3	0329-0001	7.4	25.0	0.60		0.40	0.50		0.02	0.01	13.90	0.60	0.50	0.70	0.50	1.70	0.60	0.30	0.20	0.07
Trenching Area 2	0330-0001	5.0	27.8	0.70		0.50	0.50		0.02	0.04	15.60	0.70	0.60	0.80	0.50	1.40	0.70	0.20	0.20	0.09
Trenching Area 1	0331-0001	4.4	27.5	0.80		0.40	0.50		0.02	0.02	16.20	0.70	0.60	0.70	0.70	1.80	0.80	0.20	0.30	0.04
Geophysical Area 2	0332-0001	3.0	26.9	0.50		0.40	0.40		0.02	0.02	12.90	0.60	0.50	0.70	0.50	1.50	0.50	0.20	0.20	0.07
Geophysical Area 4	0333-0001	3.6	25.6	0.60		0.40	0.50		0.02	0.01	14.90	0.60	0.50	0.70	0.50	1.70	0.60	0.20	0.20	0.06
Off-Site Soil #1	GS943770	6.2	32.7			0.20	0.70		0.03	0.60	1.10	0.80	0.70	0.90	0.70	1.30	0.80	0.30	0.30	0.10
Off-Site Soil #2	GS943771	6.5	34.2	0.80		0.05	0.80		0.03	0.70	1.10	0.90	0.80	0.90	0.70	2.00	0.80	0.40	0.30	0.10
Water Samples (pCi/L)																				
Equip. Blank (Backhoe)	0166-1001	0.6	3.0			33.00	18.00		7.40	7.60	116.40	16.90	18.60	196.00	21.60	0.50	17.40	116.90	8.60	13.10
Equip. Blank (Auger)	0246-1001	0.6	3.0			33.00	16.90		7.30	8.00	112.20	17.20	18.50	194.10	223.40	479.20	33.70	46.40	9.00	13.70
Ambient Blank	0246-2001	0.6	3.0			33.00	15.20		7.40	8.60	116.40	17.00	18.20	192.40	211.00	464.40	32.30	115.00	9.40	12.90
Equip. Blank (Scoop)	0247-0001	0.6	3.1			33.00	16.10		7.50	9.00	121.20	16.60	17.50	192.40	214.50	491.40	33.50	117.20	9.90	13.10
Equip. Blank (Bowl)	0248-0001	0.6	3.0			33.00	16.40		7.60	3.60	120.40	16.60	18.60	194.90	215.60	465.90	32.20	121.40	9.10	13.30
Off-Site Water	0314-0001	3.7	14.3			33.00	16.30		7.10	2.40	119.60	16.80	17.40	196.40	213.80	457.80	32.40	118.00	9.30	12.90

5.2.1 Explosives

A total of 40 soil samples was collected and analyzed for the explosive compounds listed in Section 3.2. No explosives or explosive by-products or degradation products were detected in any of the samples above the MDLS. The same 40 soil samples were also analyzed for cyanide, which is a common by-product of expended explosives. Cyanide was not detected in any of the samples above the MDLs. The locations where soil samples were collected for explosives and cyanide analysis, along with sample results, are identified in Table 5.5.

A plastic cord filled with white powder was found in the 3-foot to 6-foot lift of the N-S trench at Trenching Area 2. Because the powder could not be identified in the field, it could not be sent to Quantera for analysis. The sample was subsequently transported to Hall Environmental Analysis Laboratory of Albuquerque, New Mexico, for analysis of the powder. Because the tube contained only a very small quantity of powder, explosives analysis could only be done for selected compounds (TNT, 2,4-DNT, and RDX). The laboratory followed the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) procedures for analysis of the explosive compounds (Jenkins and Walsh, 1992). Estimated detection limits for the compounds are as follows: TNT - 1 ppm, 2,4-DNT - 50 ppm, and RDX - 1.4 ppm. Analysis for TNT and 2,4-DNT was negative. Analysis for RDX, an explosive compound used in detonators, was positive. The letter report from the analytical laboratory is provided in Appendix G.

5.2.2 Semi-Volatile Organic Compounds (SVOCs)

A total of 18 soil samples were analyzed by Method SW8240 for the SVOCs listed in Table 3.5. Analytical results are presented in Table 5.5. Two hand-auger samples (0140 and 0215), which were selected for laboratory analysis for SVOCs along with other constituents, were entered into the analytical laboratory sample-control system incorrectly and did not receive analysis for SVOCs. These hand-auger samples showed no positive indications for hydrocarbons during field screening, and were collected near trenching locations where other soil samples were collected for SVOC analysis. For these reasons the locations were not re-sampled for SVOCs. All SVOC concentrations were below MDLs except for the following:

- Sample 0046-0001 had 58 mg/kg napthalene and 46 mg/kg phenanthrene, and sample 0049-0001 had 0.058 mg/kg napthalene ("J" value) and 0.046 mg/kg phenanthrene ("J" value). Both samples were collected from a burned layer at a depth of 3 feet to 6 feet in

the N-S trench segment of Trenching Area 2. Burned pieces of what appeared to be railroad ties were visible in debris excavated during trenching. The constituents identified in the laboratory analysis are found in creosote, which is a common wood preservative that may have been present in the railroad ties. According to the Federal Register, neither napthalene nor phenanthrene have predetermined action levels for soil cleanup (Federal Register, 1990).

- Sample 0266-0001 had 0.80 mg/kg diethyl phthalate ("J" value). This sample was collected at the Generator Site area from a depth of 2 to 6 feet below ground surface in an area that appeared to be a test bed surrounded by concrete blocks. Because phthalates are common compounds in plastics, and because plastic bags were used as sample containers, it is possible that diethyl phthalate was detected as a result of contact of the soil with the plastic bag. Diethyl phthalate does not have a predetermined action level for soil cleanup listed in the Federal Register (Federal Register, 1990).

5.2.3 Nitrate + Nitrite

A total of 40 soil samples from HE testing locations, and two soil samples from off-site locations, were analyzed for nitrate + nitrite (reported as N total). Nitrate + nitrite concentrations in the on-site soils range from 0.58 mg/kg to 386 mg/kg (Table 5.5). However, only seven samples had nitrate + nitrite concentrations above 10 mg/kg, and only four samples had nitrate + nitrite concentrations above 25 mg/kg. Nitrate + nitrite concentrations in the two off-site soil samples were 0.43 mg/kg and 0.79 mg/kg. While there are no Federal SALs for nitrate and/or nitrite, Sandia National Laboratory (SNL) has set risk-based action levels for nitrate and nitrite in soils at 100,000 mg/kg and 8,000 mg/kg, respectively (Table 5.8). The concentrations in the soils sampled at McCormick Ranch are well below the SALs set by SNL, and the slightly elevated concentrations found across the site may be a result of livestock. The four sampling locations with nitrate + nitrate concentrations above 25 mg/kg are described in the following paragraphs.

Table 5.8 Soil Action Levels (SALs) for Selected Analytes

Analyte	Federal Standard (1) (PPM)	Sandia National Lab Risk-Based Standard (2) (PPM)	Kirtland AFB RCRA RFI Stage 2A Risk-Based Standard (3) (PPM)
Napthalene	-	-	-
Phenanthrene	-	-	-
Pentachlorophenol	2000	6	-
Aluminum	-	-	-
Antimony	30	30	32
Arsenic	80	20	24
Barium (ionic)	4000	6000	5600
Beryllium	0.2	0.2	0.2
Cadmium	40	80	40
Calcium	-	-	-
Chromium	400 (+6)	80000 (+3), 400 (+6)	80000 (total), 400 (+6)
Cobalt	-	-	-
Copper	-	-	-
Iron	-	-	-
Lead	-	-	-
Magnesium	-	-	-
Manganese	-	-	400
Mercury	20	20	20
Molybdenum	-	400	400
Nickel	2000	2000	1600
Potassium	-	-	-
Selenium	400	400	400
Silver	200	400	400
Sodium	-	-	-
Thallium	-	-	6.4
Vanadium	-	600	-
Zinc	-	20000	24000
Cyanide, Total	2000	2000	-
Nitrate + Nitrite (as N)	-	8000 (NO2), 100000 (NO3)	-

(1) (Federal Register, 1990) Federal Register, Vol. 55, No. 145, Friday, July 27, 1990, pp. 30865-30867

(2) Sandia National Laboratory internal document, unpublished.

(3) (USGS, 1993b) RCRA RFI, Stage 2A, Volume 1, Technical Report, USGS, December 1993.

- No Soil Action level has been specified for the constituent.

Sample 0084-0001 had a nitrate + nitrite concentration of 95.4 mg/kg (and the duplicate at the location, 0084-0002, had a concentration of 87.4 mg/kg). This hand-augering location is situated in a depression in Geophysical Area 1 that was possibly created by one of the HEST tests. Geophysical surveys showed subsurface debris at the location. Because the sampling location is in a surface depression, the area around the sampling location collects water and is frequented by livestock that may contribute to the elevated nitrate + nitrite levels.

Sample 0254-0001 had a nitrate + nitrite concentration of 386 mg/kg. This hand-auger sample was collected in the DIP 5 area, where large quantities of sodium nitrate and ammonium nitrate were reportedly flushed onto the ground surface.

Sample 0284-0001 had a nitrate + nitrite concentration of 68.6 mg/kg. This hand-auger sample was collected in an open area approximately 15 feet north of the Art Test locations. None of the documented test materials would appear to have contributed to the elevated concentrations.

Sample 0307-0001 had a nitrate + nitrite concentration of 46.8 mg/kg. This hand-auger sample was collected from the edge of a large crater in the SSTM Add-On area, where sodium nitrate and ammonium nitrate were documented test materials.

5.2.4 Metals

A total of 40 soil samples from HE testing locations, and two soil samples from off-site locations (Table 5.4), were analyzed for the metals listed in Table 3.5.

For metals constituents where Federal SALs, SNL risk-based SALs, and RCRA risk-based SALs for the Stage 2A RFI at Kirtland AFB have been published (Table 5.8); the concentrations of metals in the soils analyzed at the McCormick Ranch site are at least one order of magnitude (ten times) lower than the reported SALs with the following exceptions. Manganese concentrations at three locations in Trenching Area 2 (0046-001 [408 mg/kg], 0047-0001 [445 mg/kg], and 0047-0002 [420 mg/kg]) are above the Kirtland AFB Risk-Based Standard of 400 mg/kg. The remaining manganese concentrations in the soil range from 71.1 mg/kg to 272 mg/kg. Arsenic concentrations, which average 3.3 mg/kg, are approximately four times lower than the SALs.

Trenching Area 2 and the DIP 5 Area had the highest concentrations of metals when compared to other sampling areas. In Trenching Area 2, samples 0046-0001 and 0047-0001 (and 0147-0002, duplicate) had the highest levels recorded of the following constituents: arsenic, chromium, cobalt, copper, iron, lead, manganese, nickel, and zinc (Table 5.5). The two samples identified in Trenching Area 2 were collected from what appeared to be a debris burn and burial area, and large quantities of metal were excavated during trenching. In the DIP 5 Area, sample 0254-0001 had the highest recorded levels of barium and calcium. The DIP 5 tests required the drilling of numerous deep boreholes, and the constituents of the drilling fluids (mud) may have been a source of these constituents. However, with the exception of manganese in three samples in Trenching Area 2, all metals concentrations were below published SALs.

5.2.5 Radiation and Radionuclides

A total of 17 on-site composite soil samples were analyzed for gross alpha, gross beta, and specific radionuclides by gamma spectrometry. For each trenching area and hand-augering area, 50 to 400 grams of soil were collected from each sampling location in the area and then composited with soils from the other sampling locations in the area. Analytical results for two off-site soil sampling locations (gross alpha, gross beta, and specific radionuclides by gamma spectrometry) were also obtained from the Kirtland AFB Bioenvironmental Office to use for comparison. These two off-site radionuclide soil sampling locations are not the same as the locations where off-site soil samples were collected and analyzed for nitrate and metals, but are separate locations on Kirtland AFB where the Bioenvironmental Office had collected background samples. The radiological analytical results are summarized in Table 5.7. The radionuclide data reports from Armstrong Laboratory are provided in Appendix H.

Results of the radiological analysis of the soil samples show that the soils at McCormick Ranch are at background levels for the full suite of radionuclides that were investigated. Gross alpha levels on-site were consistently low, ranging from 2.2 to 7.4 picocuries per gram (pCi/g). The on-site numbers are similar to the off-site samples, where gross alpha levels were 6.2 and 6.5 pCi/g. Similarly, on-site gross beta levels were low, ranging from 20.6 to 29.5 pCi/g. These numbers are similar to the off-site samples, where gross beta levels were 32.7 and 34.2 pCi/g.

The potassium-40 levels in both off-site samples were 1.1 pCi/g, while the potassium-40 levels in the on-site samples ranged from 11.5 to 16.9 pCi/g. However, the off-site samples were collected in sandier soils, and the higher levels of potassium-40 in the on-site samples are

probably a result of higher clay content in the soil. Clays are often a weathering product of potassic feldspars and contain naturally occurring potassium-40. When clay-rich soils are analyzed for potassium-40, they have elevated levels in comparison to sandier soils. No SALs for potassium-40 are available, and the concentrations found in the on-site soils can be considered background.

5.2.6 QA/QC Requirements

Quality control data provide information for identifying and defining qualitative limitations associated with measurement data. Detailed QA/QC requirements and results evaluated by the Quanterra QA officer are presented in Attachment 2. Laboratory QC data are presented in Appendix I.

6.0 SUMMARY AND CONCLUSIONS

6.1 Summary

A site selection process was conducted at the outset of the Phase II EBS to identify HE test sites at McCormick Ranch with the greatest potential for containing contaminants of concern in the soil. The site selection process began with a review of historical HE testing information collected during the Phase I EBS, and was followed by interviews and field reconnaissance with people having first-hand knowledge of the testing programs at the site. Test areas were then ranked according to their potential for containing contaminants of concern in the soil. Several surface and near-surface tests were accurately located at the site during the preliminary investigation, and did not require geophysical surveys. However, the locations of some of the larger subsurface tests could only be approximated. Geophysical surveys were conducted at five areas to pinpoint the locations of the larger subsurface tests. The geophysical surveys identified numerous subsurface anomalies in areas of known testing, and four of the largest anomalies were investigated for soil contamination through trenching and soil sampling. The site selection process and the geophysical surveys also identified 13 HE test areas were investigated through hand-augering and soil sampling were performed and the geophysical surveys to evaluate contaminant levels in the soils. The site selection process and the geophysical surveys indicated 13 additional HE test areas of concern. Hand augering and soil sampling were performed in these areas to evaluate for soil contamination.

A total of 312 soil samples were collected using trenching and hand-augering methods. During sampling operations, soil types and any test debris encountered were logged. A 5-foot thick calcium carbonate horizon (caliche) was encountered across the site beginning at a depth of between 3 feet and 5 feet below ground surface. Because a thick caliche layer generally takes thousands of years to form, the caliche was used as an indication of when undisturbed soils had been reached in the trenches and auger holes. The caliche layer may serve as a barrier to the downward migration of contaminants. Contaminants would be more concentrated at the surface of the caliche layer. Most soil samples were collected from the interval slightly above to just into the caliche layer.

The soil samples collected from the trenches and auger holes were first screened in the field for TNT and TNT degradation products, nitrates, PETN, SVOCs, and radioactivity (alpha, beta, and gamma). Selected samples were then sent to a EPA certified laboratory for more detailed analyses for explosives, nitrate + nitrite, SVOCs, cyanide, and/or metals. Composite soil

samples from each of the four trenching areas and 13 hand-augering areas were also sent to an analytical laboratory and analyzed for gross alpha, gross beta, and specific radionuclides by gamma spectrometry.

6.2 Conclusions

Geophysical methods, trenching, hand-augering, and site reconnaissance during the Phase II EBS identified an abundance of test debris (metal, wood, concrete, rebar, wiring, cables) on the surface and in the shallow subsurface. Based on information gathered during the Phase II EBS, surface debris removal operations in each of the geophysical survey areas would only clean up a portion of the total amount of test debris present in each area. The remainder of the debris is buried primarily in the top 2 to 3 feet of soil. In Geophysical Area 1 (Trenching Areas 1 and 2), however, large quantities of burned wood, metal, concrete, and rebar were found at depths of up to 12 feet. At Trenching Area 1, small amounts of concrete and rebar debris were still present at 12 feet below ground surface in one trench segment, but the backhoe could not reach far enough to continue trenching.

There are previous reports of artillery projectiles and other unexploded ordnance found at the site (Ken Bell, personal communications, 1993). However, no ordnance items were encountered during the Phase II EBS investigation. Because screening for unexploded ordnance was accomplished only in areas selected for study during the Phase II investigation, the occurrence of ordnance across the site is unknown.

Trenching identified the types of buried debris that are present within the areas investigated, which cover the largest geophysical anomalies identified. The trenching could not provide an exact means of quantifying the amount of debris that may be present in the subsurface because of the small area covered relative to the surface area of the geophysical anomalies. Approximately 300 square feet of surface area was trenched out of 10,000 square feet of surface area covered by the three geophysical anomalies.

No explosives residues were visibly identified in the soils during the field investigations. Field screening and laboratory analysis of soil samples did not identify explosives or explosive degradation products in the soils at the selected sampling locations. However, analysis of a white powder found in a hollow plastic cord during excavation in Trenching Area 2 confirmed the presence of RDX, an explosive compound used in detonators.

SVOCs (naphthalene and phenanthrene) were detected in two soil samples in Trenching Area 2. They are most likely related wood preservatives from a burned railroad tie adjacent to where the samples were collected. One SVOC (diethyl phthalate) was detected in a soil sample at the Generator Site. However, because diethyl phthalate is an ingredient in plastics and because it was detected in low concentrations (0.80 mg/kg); the PQL is 0.77 mg/kg), this chemical was probably introduced into the soil sample from the sample containers.

Metal concentrations in the soil samples were well below the published EPA, Kirtland AFB, and Sandia National Laboratories SALs, with the exception of manganese concentrations in three samples at Trenching Area 2 that exceeded Kirtland AFB SALs. The elevated manganese concentrations were possibly a result of localized disposal and burning of metallic test debris. The elevated concentrations of arsenic, chromium, copper, iron, lead, manganese, nickel, and zinc at Trenching Area 2 are possibly due to the burning and disposal of metallic debris such as rebar, cable, wiring, and spools. Metal concentrations were generally higher in soil samples collected at Trenching Area 2 than in other sampling areas.

Nitrate + nitrite concentrations were elevated at several locations on-site, but were still several orders of magnitude below the SALs used by Sandia National Laboratories (the only identified source with a Soil Action Level for nitrate or nitrite in soil). The highest concentrations of each metal constituent, along with the highest concentration of nitrate + nitrite, were found at the DIP 5 Test area. The elevated concentrations of barium, calcium, and nitrate + nitrite in soils at the DIP 5 Test area are possibly from drilling muds that were used to conduct the boreholes, and from test materials that were flushed onto the ground surface.

Results of radiation screening of on-site soils indicate that alpha, beta, and gamma levels were at background in the soils. Laboratory analysis of composited soil samples indicated that all radionuclides were at background levels.

Results of the laboratory analyses for nitrates, TNT, PETN, SVOCs and radioactivity compare favorably to the results obtained during field screening. Nitrate concentrations obtained during laboratory analysis were reproducible (average of 40% RPD) to the nitrate results obtained during field screening, and all TNT samples were below the MDL during both field screening and laboratory analysis. A total of seven soil samples tested positive for hydrocarbons (PETN and/or SVOCs) during field screening, and laboratory analysis of those samples for PETN and SVOCs confirmed that two of the samples contained SVOCs above the detection limits of the analytical instrument. While one sample tested negative for hydrocarbons during field screening

but later tested positive for SVOCs during laboratory analysis, it is believed that the SVOC (a phthalate) was related to a plastic bag sample container and was not detected during field screening.

Surface water sampling could not be conducted within the playa due to a lack of sufficient precipitation. However, approximately half of the soil samples were collected from within the historic playa area and analytical results identified only minor contamination. It is unlikely that intermittent runoff on-site becomes contaminated because of contact with on-site soils.

At McCormick Ranch, groundwater is found under unconfined conditions at over 350 below ground surface. The water table aquifer beneath the site is part of the regional aquifer within the upper unit of the Santa Fe Group. The Santa Fe Group consists of unconsolidated to semiconsolidated clay, sand, and gravel deposits. Water levels in existing monitoring wells at the site indicate that groundwater flow is to the north-northwest. Since 1992, water levels have declined in these wells at an average rate of 1.8 feet per year as a result of pumping from production wells located north of the site. Groundwater discharge from the City of Albuquerque and Kirtland AFB production wells has resulted in a change in the direction of groundwater flow from west-southwest to north-northwest.

The potential for contaminants to reach the water table is low based on the following:

- surface recharge is minimal because evapotranspiration exceeds precipitation and because no surface channels are present at the site to concentrate runoff,

- the vadose zone is over 350 feet thick, and

- most contaminants of concern have either low persistency or low mobility in the environmental setting at the site.

The DIP 5 Test is the only HE test identified which has the potential for impacting groundwater quality. Investigations at the DIP 5 Area focused on surface and near-surface soils that could have been affected by the flushing of gelled explosives onto the ground surface. It is possible that some material was flushed downward when the initial explosive mixture was flushed out of the casings. However, based on a seepage velocity of 2.6 feet per year, estimated for a nearby facility, contaminant migration in the aquifer would be less than 60 feet beyond the point of entry into the aquifer. This estimate assumes no additional travel time through the vadose zone and no

dispersion, diffusion, or retardation effects which would slow the migration of contamination in the direction of groundwater flow.

All sampling locations were surveyed at the conclusion of the field investigations, and have been plotted on a McCormick Ranch site map (Plate 1). If further action is required to investigate or mitigate conditions at any sampling location, the location can be readily found in the field.

The Phase II EBS geophysics and soil sampling programs investigated selected HE test locations at the McCormick Ranch site. The site selection process (including the geophysical investigations) identified HE test locations with the greatest potential for containing contaminants in the soil. Soil samples were collected from all these locations during the trenching and hand-augering activities. The only soil contaminants identified were in Trenching Area 2, a debris disposal area apparently related to one of the HEST tests. No other contaminants were identified in the soil at the selected HE test areas that were investigated. Because only minimal soil contamination was found in areas of greatest concern, it is unlikely that contamination would be found in soils at the remaining HE test areas of lesser concern.

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ATTACHMENT 1

Regional and Local Hydrologic Study
Phase II Environmental Baseline Survey of McCormick Ranch

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Regional and Local Hydrologic Study
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1.0 INTRODUCTION

A study of the regional and local hydrogeology of the McCormick Ranch site was performed as part of the Phase II Environmental Baseline Survey (EBS). A detailed evaluation of pertinent data from recent hydrologic investigations was used to evaluate the potential for contaminant migration in the unsaturated zone and water table aquifer beneath the site. Field activities for this study were limited to measuring water levels in the five monitoring wells located at McCormick Ranch.

2.0 Regional Hydrology

2.1 Climate

The McCormick Ranch site, adjacent to the southwest boundary of Kirtland Air Force Base (AFB) is situated on the westward sloping basin floor of the Albuquerque Basin about half way between the foot of the Manzanita Mountains, 6 miles to the east, and the southward flowing Rio Grande, 6 miles to the west. Climate in the basin varies with elevation, with generally increasing precipitation and decreasing temperature at higher elevation. The elevation of McCormick Ranch is about 5,250 to 5,280 feet above mean sea level (amsl). Climatic conditions at the site are similar to those measured at the Albuquerque International Airport weather station, located about 4 miles to the north at an elevation of about 5,300 feet amsl. The average annual precipitation at the airport is 8.8 inches (NOAA, 1993). The months with the greatest precipitation are July, August, and September, with most rainfall occurring as thunderstorms (Thorn and others, 1993). Because these storms are often very localized, precipitation amounts may vary widely over small areas. Rainstorms can be very intense, with several inches deposited within a few hours. Flash flooding in arroyos and overland flow may occur during such events.

The mean annual temperature at the airport weather station is about 56 degrees Fahrenheit. Mean monthly temperatures range from a low of 35 degrees Fahrenheit in January to a high of 79 degrees Fahrenheit in July.

The annual potential evaporation at the McCormick Ranch site is about 60 inches (Thorn and others, 1993). The annual potential evapotranspiration in the Albuquerque Basin varies from about 40 to 48 inches (Gabin and Lesperance, 1977), greatly exceeding precipitation in the basin.

Wind direction is generally from the north in the winter and from the south in the spring and summer. Spring is the windiest season of the year, although strong winds often occur briefly prior to summer thunderstorms. The annual average wind speed is nine miles per hour (Hacker, 1977).

2.2 Surface Water

The Rio Grande is the only perennial stream on the Albuquerque Basin floor. Westward discharging drainage systems from the mountains along the east side of the Albuquerque Basin are all ephemeral on the basin floor, flowing briefly only in response to local precipitation. Tijeras Arroyo, Arroyo del Coyote, and an unnamed drainage south of Arroyo del Coyote are the major surface drainages on Kirtland AFB (Figure 1). Hells Canyon Wash is the nearest major surface drainage south of Kirtland AFB. McCormick Ranch is situated about 5 miles south of Tijeras Arroyo and about 4 miles north of Hells Canyon Wash. There are no surface drainage channels that carry runoff onto McCormick Ranch.

2.3 Hydrogeologic Setting

Albuquerque and Kirtland AFB are located on the eastern portion of the Albuquerque Basin, one of a series of north-trending sediment-filled depressions formed in association with the Rio Grande rift system. The Albuquerque Basin is approximately 100 miles long and ranges from 10 to 40 miles wide. The basin contains up to 14,000 feet of silt, sand, and gravel of the Upper Cenozoic Santa Fe Group which were deposited as the basin subsided along numerous basin-bounding normal faults (Hawley and Haase, 1992).

Hawley and Haase (1992) divided the Santa Fe Group into lower, middle, and upper units. During deposition of the lower and middle units of the Santa Fe Group in the Albuquerque Basin, most of the sedimentation consisted of clastic deposition from the surrounding highlands into a basin that probably was closed (internal drainage; no surface-water outflow). These sediments were deposited from about 30 to 5 mega-annum (Ma)(million years before present). Deposition of the upper unit of the Santa Fe Group began when the Rio Grande became a through-flowing stream that carried sediments from basins to the north into the Albuquerque Basin and beyond. Sedimentation from the surrounding highlands continued during this time, resulting in intertongued Rio Grande alluvium and clastic sediments from the highlands. Deposition of the upper Santa Fe Group took place from about 5 to 1 Ma and resulted in deposition of up to 1,200 feet of sediments.

Kirtland AFB is located near the east margin of the Albuquerque Basin floor on a series of shallow benches. These are fault blocks that have less downward displacement and sediment accumulation than the central part of the basin to the west. The current conceptual model of the structure and stratigraphy one mile north of and parallel to the Kirtland AFB south boundary is shown on the "Pajarito Section" (Plates 1 and 5) of Hawley and Haase (1992). This cross section runs through the northern part of McCormick Ranch, and across the Rio Grande to the west.

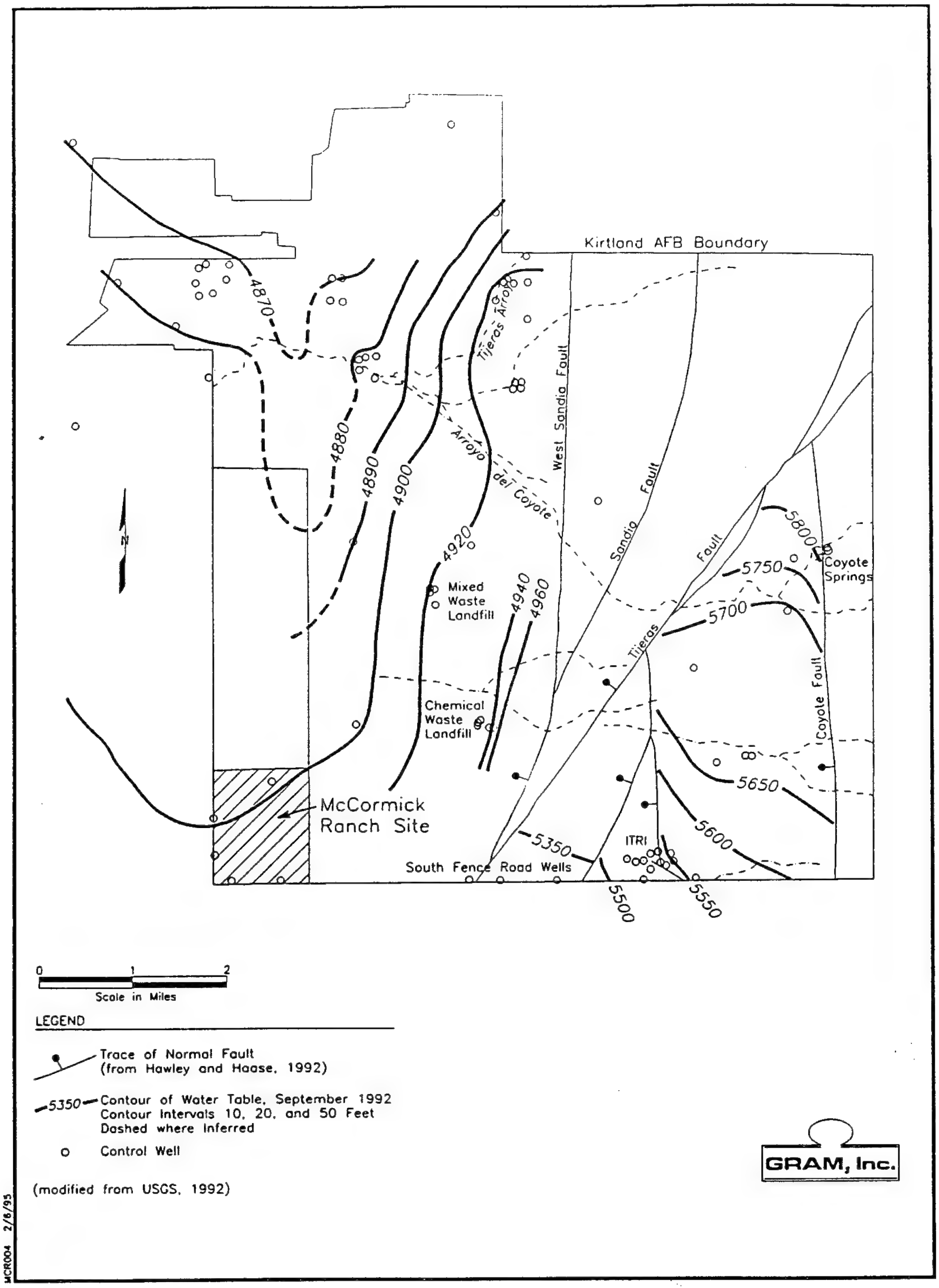

Figure 1. Generalized Regional Water Table for Kirtland AFB, September 1992

Sediment thickness varies from less than 50 feet in the eastern part of Kirtland AFB (exclusive of the U.S. Forest Service withdrawal lands of the Manzanita Mountains) to over 5,000 feet along the west boundary of Kirtland AFB (Hawley and Haase, 1992). Cross sections from Hawley and Haase (1992) show an estimated thickness of more than 1,000 feet of upper unit Santa Fe Group sediments and about 4,000 feet of middle and lower unit Santa Fe Group.

McCormick Ranch is situated on a downfaulted bench that extends about two miles to the east of the property to the Tijeras fault zone (Figure 1) and about one mile west to an unnamed fault. The mapped faults to the east, along with possible unmapped faults are probably the reason for a water level difference of over 400 feet from east of the Tijeras fault zone (higher water level) to McCormick Ranch (lower water level). There is probably little or no affect on groundwater flow across an unnamed fault west of McCormick Ranch as evidenced by the lack of water level change from the site to the Rio Grande. Water levels were between 350 and 380 feet below land surface (elevations between 4,890 and 4,900 feet amsl) in the five monitoring wells installed by the U.S. Geological Survey for the Kirtland AFB Stage 2A RCRA Facility Investigation (RFI) (USGS, 1993).

The major aquifers in the vicinity of Albuquerque and Kirtland AFB lie within the sediments of the Santa Fe Group, primarily within the ancestral Rio Grande sediments of the upper Santa Fe Group. The Rio Grande sediments are generally better sorted and cleaner than the clastic sediments from the marginal highlands, and therefore have greater hydraulic conductivity than the clastics. Thorn and others (1993) mapped the area of greatest hydraulic conductivity within the area of "axial channel deposits of the ancestral Rio Grande."

The regional groundwater flow pattern has been altered over the last few decades by extensive pumping from City of Albuquerque wells, and to a lesser extent from pumping of Kirtland AFB production wells. Prior to 1960, groundwater east of the Rio Grande flowed generally to the southwest through the Albuquerque and Kirtland AFB areas (Thorn and others, 1993), and flow through the McCormick Ranch area was presumably to the west. However, due to drawdown resulting from pumping of city and Kirtland AFB production wells, the groundwater flow direction has changed markedly in much of the Albuquerque/Kirtland AFB area. Groundwater flow now is toward pumping centers in east or southeast Albuquerque, resulting in flow to the west and northwest across most of Kirtland AFB and to the north along the west margin of the base, including the McCormick Ranch area.

Water levels have declined by 60 to 100 feet in areas of southeast Albuquerque adjacent to Kirtland AFB, and up to 140 feet in areas near Albuquerque since 1960. Water level declines appear to vary in relation to fault proximity and aquifer materials (Thorn and others, 1993). The rate of decline for most Kirtland AFB and Sandia National Laboratories (SNL) monitoring wells is between 0.5 and 2.0 feet per year. It is likely that the greater water level declines are in sediments which have better hydraulic connection with the Albuquerque and Kirtland AFB well fields.

3.0 SITE HYDROLOGY

3.1 Recent Investigations

Currently, very little specific information is available on the hydrogeology of the McCormick Ranch site. The Kirtland AFB RFI included McCormick Ranch as one of 18 sites investigated. The purpose of the RFI was to determine if the explosive testing at the site had impacted groundwater beneath the site (USGS, 1993). Five wells were installed at McCormick Ranch as part of the RFI. Data collected includes lithologic and geophysical logs, soil analyses, groundwater analyses and slug test results. Pertinent information from the RFI study at McCormick Ranch will be included in the following sections.

The Phase I EBS study for McCormick Ranch (LATA, 1993) concluded that the potential for groundwater contamination at the site is low because most HE tests were conducted at the ground surface or at shallow depths and the groundwater beneath the site is deep (>300 feet). Activities for the Phase II EBS have focused on locating and identifying subsurface debris related to HE testing, and sampling soils to depths of 12 feet for contaminants of concern. Collection and evaluation of hydrogeologic data at the site was beyond the scope of the Phase II EBS. With the exception of water level measurements in the five onsite wells, no field work was performed during the Phase II EBS to collect hydrologic data at the site. Surface water sampling of rainfall runoff was planned if precipitation created ponding at the site in sufficient quantities to sample. However, for the duration of the Phase II EBS field work no significant ponding occurred.

Because information is scarce on the hydrogeologic conditions at McCormick Ranch, results from hydrogeologic investigations conducted at nearby facilities were reviewed. Technical Area 3 (TA-3), leased and operated by Sandia National Laboratories, is located approximately 2.5 miles northeast of McCormick Ranch (Figure 1). TA-3 is situated in the same general hydrologic setting as McCormick Ranch. The Upper Santa Fe Group underlies this area, as it does McCormick Ranch, and groundwater is encountered at about the same depth in both areas. The Chemical Waste Landfill (CWL) and the Mixed Waste Landfill (MWL) are located within TA-3. The CWL is currently complying with RCRA interim groundwater monitoring regulations and adhering to a Compliance Agreement with the New Mexico Environment Department (SNL, 1991). As part of their Compliance Agreement, SNL has performed laboratory analyses for hydraulic conductivity on soil samples from the unsaturated and saturated zones. SNL is also performing hydrogeologic investigations at the MWL to conform to RCRA regulations (SNL, 1990). Hydrologic properties from these investigations are useful for estimating conditions at McCormick Ranch and so will be discussed in the following sections.

Hydrogeologic investigations are also being conducted by SNL approximately 1.7 to 3.0 miles east of the site, along South Fence Road. A series of wells have been installed on the southern boundary of Kirtland AFB to investigate the effects of the Sandia and Tijeras faults on groundwater flow. Some results from these investigations are pertinent to hydrologic conditions at McCormick Ranch and will be discussed in the following sections.

3.2 Surface Water

There are no water bodies or significant drainage features on McCormick Ranch. The site is almost featureless with only 30 feet of difference in elevation between its lowest and highest points (excluding manmade features). The lowest portion of the site is on its southern boundary. In this area, a topographic depression is present and is interpreted as a playa (ephemeral, usually dry lake) on the topographic map for the area (USGS, 1974). Under undisturbed conditions, rainfall runoff would tend to drain to this area and accumulate. Suspended sediments would then settle out and most of the ponded water would evaporate, with some percolation into the subsurface. Based on observations during the Phase II EBS, the natural surface drainage has been significantly altered by grading, trenching, and road construction during the site's operation. Surface drainage does not appear to have well defined pathways. During the few storms which occurred during the Phase II EBS, rainfall pooled in localized areas where trenches and holes have been dug or depressions have formed from explosive testing. Most of these pools appeared to evaporate and /or infiltrate within a few days. The playa area had some moderately large pools of standing water which remained for several weeks. The surface and shallow clay-rich soil in the playa area was easily saturated and appears to be less permeable than soils outside of this area. The effects of runoff from a very large storm or series of storms was not observed during this investigation.

3.3 Vadose Zone

The vadose zone, often referred to as the unsaturated zone, occurs between the ground surface and the saturated groundwater system. The water table, defined as the surface on which the fluid pressure in the pores is exactly atmospheric, is the boundary between the vadose zone and the saturated zone (Freeze and Cherry, 1979). The vadose zone is a significant part of the hydrologic system at Kirtland AFB where its thickness ranges from 50 feet in the eastern part of Kirtland AFB, to over 500 feet in the western portion. Based on water level data from wells located at the site, the vadose zone at McCormick Ranch ranges from about 350 to 380 feet thick. Contaminants released on the surface must migrate through this thickness before reaching the saturated zone. Prediction of travel times through the vadose zone is difficult due to heterogeneous, layered sediments and unknown nature of the volume and distribution of infiltration.

Hydraulic characteristics of the vadose zone at nearby sites may be indicative of conditions that exist at McCormick Ranch. Hydraulic characteristics of the vadose zone at the CWL were determined from core samples during drilling of one of the wells (SNL, 1991). The saturated hydraulic conductivity values derived from analysis of core ranged from 0.2 to 11 ft/day. The actual range of the hydraulic conductivity was considered to be greater than this range due to poor core recovery of coarse-grained layers.

The natural seepage flux for the vadose zone beneath the CWL was calculated to be approximately $3x10^{-6}$ ft/day. In the absence of deep evapotranspiration (e.g. from tree roots), the ambient unsaturated seepage flux may be approximated by the natural recharge rate. This value agrees with published recharge rates in the Albuquerque area of $8x10^{-6}$ to $6x10^{-5}$ ft/day, or approximately 0.5% to 3% of the annual precipitation (SNL, 1991). The natural seepage flux calculated for the vadose zone at the CWL can be extrapolated to the McCormick Ranch site because of the proximity of the CWL to McCormick Ranch and their similar environmental settings (see Figure 1).

3.4 Site Hydrogeology

Five wells (KAFB-1001 through -1005) were installed in 1992 for the Kirtland AFB RFI (Figure 2). The wells were completed in upper unit of the Santa Fe Group sediments to depths ranging from 377 to 398 feet. The lithogic logs from these wells indicate that the Upper Santa Fe Group sediments are primarily gravel interbedded with discontinous beds of poorly sorted, clayey or silty sand and gravel. None of the soil and groundwater from the five RFI monitoring wells at McCormick Ranch contained elevated levels of contaminants of concern (USGS, 1993). Wells KAFB-1004 and KAFB-1005 are located downgradient of the explosives testing areas. However, KAFB-1005 may be the only well located within a flow path of explosives tests.

Two distinct stratigraphic zones of the upper unit of the Santa Fe Group were identified from interpretation of the geophysical and lithologic logs. These zones appear to be continuous between the five wells. The upper zone extends from near land surface to approximately 150 feet and consists of sand and gravel with volcanoclastics. This zone is interpreted as ancestral Rio Grande deposits. The lower zone is characterized by coarser sand and gravel. This unit is interpreted as alluvial fan and piedmont sediments (Van Hart, 1994).

The depth to the water table is approximately 350 to 380 feet below ground surface. Monthly water levels were measured from June of 1992 through December of 1993 by the USGS. Water levels were measured in the five wells for the Phase II EBS on October 26, 1994. Table 1 shows the water level elevations for this date. A water level contour map of these measurements is shown on Figure 2. The water-level elevations shown are derived from the recent land survey performed at the site for the Phase II EBS. Top-of-casing elevations from the Phase II EBS survey were consistently lower (by up to four feet) than the survey results from the Kirtland AFB IRP investigation (USGS, 1993). If additional wells are installed at the site the existing wells should be resurveyed. Regardless of the survey reference used, the groundwater flow direction is to the north. The hydraulic gradient is 0.001.

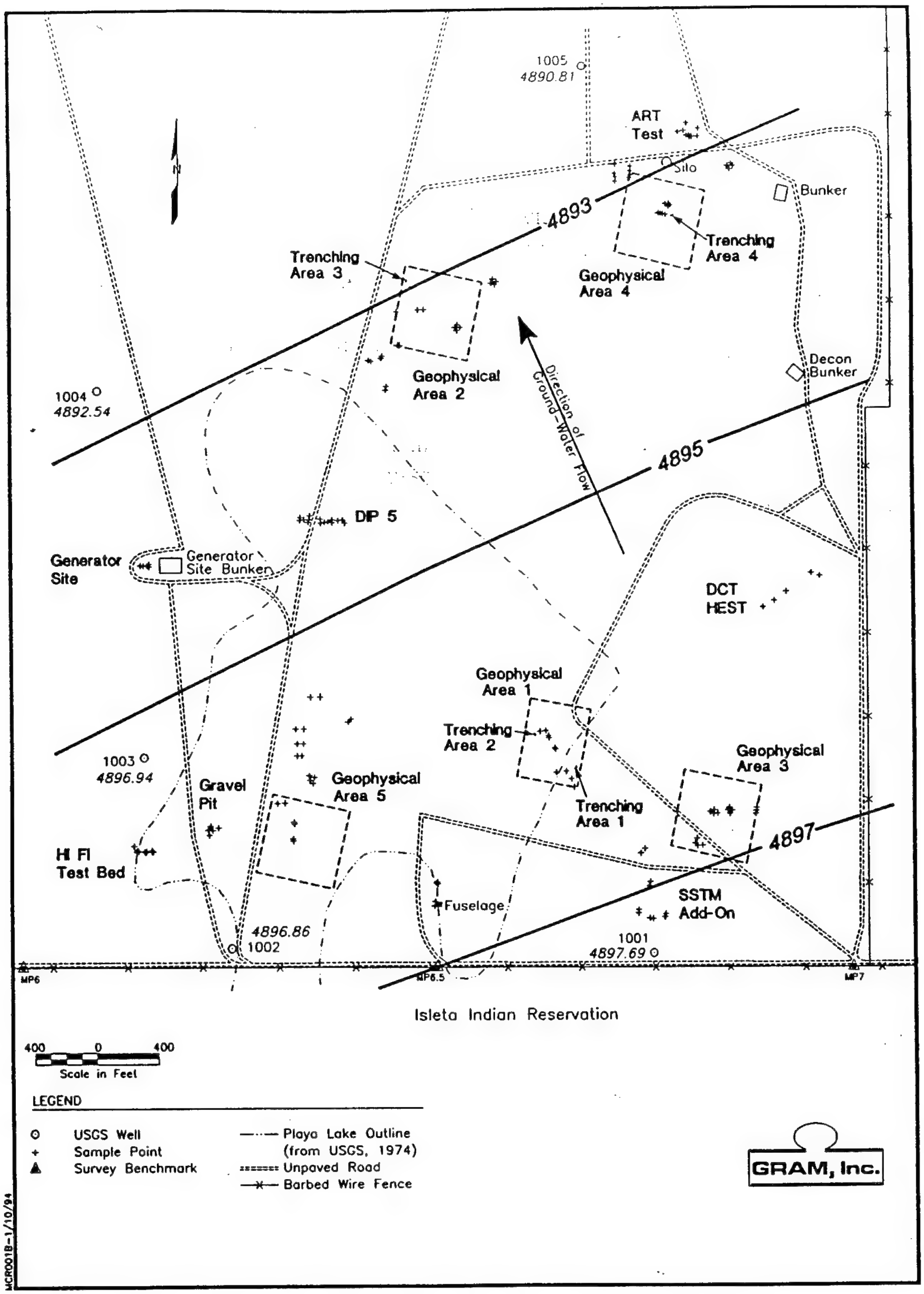

Figure 2. Water Table Contour Map, October 25, 1994

Table 1. Water Level Elevations at McCormick Ranch for October 25, 1994

Well Name	Well Casing Elevation (feet above msl)	Depth to Water (feet below m.p.)	Water Level Elevation (feet above msl)
KAFB-1001	5257.79	360.10	4897.69
KAFB-1002	5251.66	354.80	4896.86
KAFB-1003	5253.3	356.86	4896.44
KAFB-1004	5253.94	361.40	4892.54
KAFB-1005	5268.84	378.03	4890.81

Note: Elevations for wells from the Phase II EBS elevational survey conducted in September, 1994. These elevations differ from the USGS (1992) RFI survey.

msl - mean sea level
m.p. - measurement point (top of well casing)

Slug test results from the Kirtland AFB RFI provided a range of saturated hydraulic conductivity of 0.74 to 10.46 ft/day for the wells at McCormick Ranch (USGS, 1993). Slug tests only provide hydraulic conductivity values for the area immediately surrounding the well and so are not as reliable as pumping tests for estimation of aquifer properties. Hydraulic properties for the saturated zone also were estimated at the nearby CWL by Sandia National Laboratories (SNL, 1991). Transmissivity values for the saturated zone at CWL were calculated from results of a 35-day aquifer pumping test using numerical and analytical solutions (SNL, 1991). A transmissivity value of 6.2 ft^2/day was calculated. The saturated hydraulic conductivity value was estimated at 0.39 ft/day. This results in a seepage velocity of 2.6 ft/yr. A hydraulic gradient of 0.005 was used to calculate the seepage velocity. The vertical seepage velocity was estimated to be 0.6 ft/yr. Using a one-dimensional advective dispersive equation for prediction of migration of a non-reactive tracer (R=1.08), a migration rate of 5 ft/yr was calculated by SNL (1991) for the shallow saturated zone underlying the CWL. Results from the RFI slug tests and from the CWL aquifer pumping tests indicate moderately conductive aquifer material. Because the hydraulic gradient is low in the area of McCormick Ranch and the CWL groundwater movement is slow, contaminant migration by means of groundwater transport will also be slow under present conditions.

Water level decline at McCormick Ranch before 1992 is unknown due to lack of data in that area. However, water levels during 1992-1994 are declining steadily at about 1.8 ft/yr in the five RFI wells. Wells at the CWL and MWL show a similar rate of decline from 1986 to the present. Figure 3 shows decreasing water levels over time in all five of the McCormick Ranch monitoring wells. This trend is consistent with a one-half- to two-foot decline in water levels at wells on

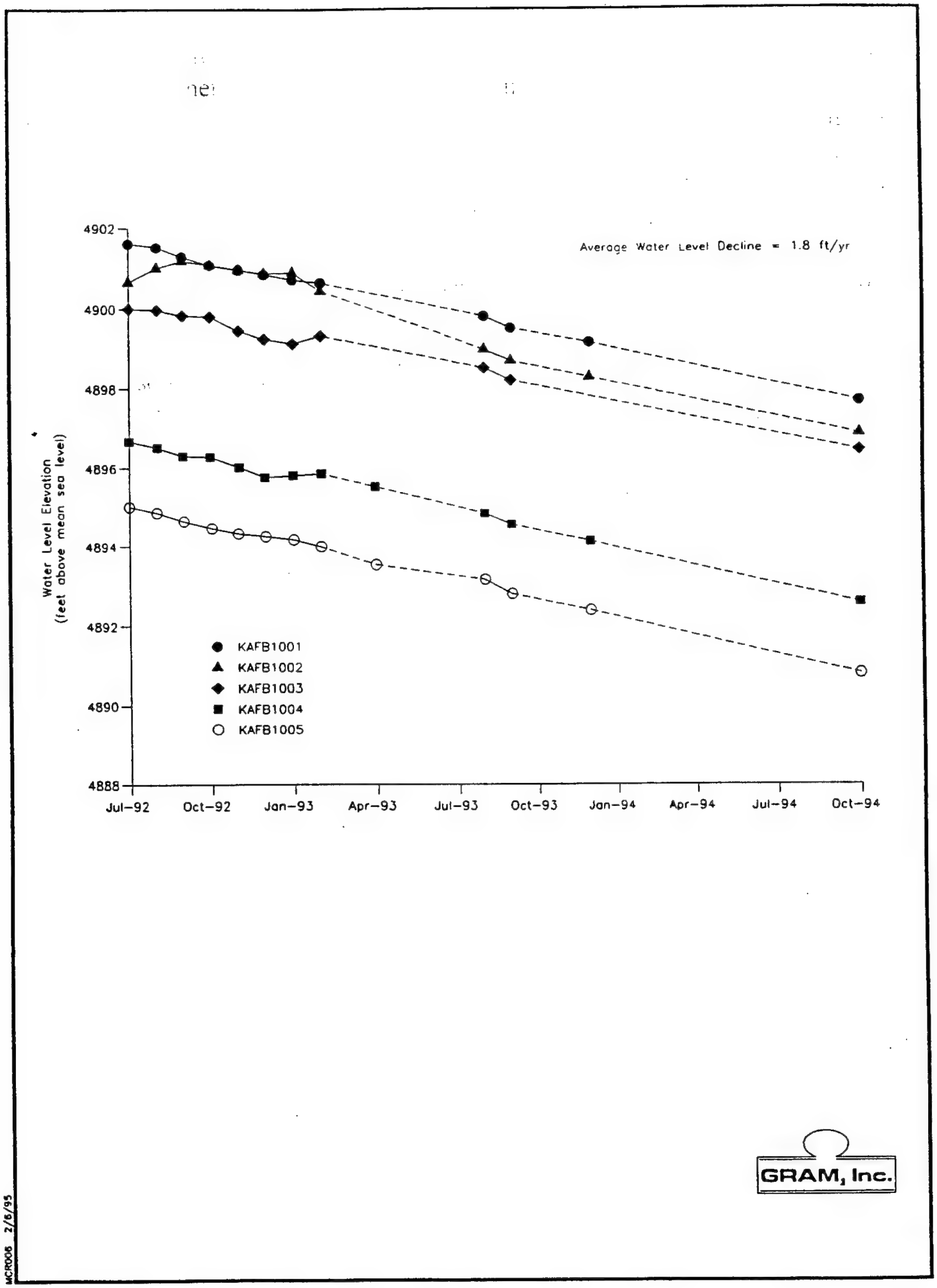

Figure 3. Hydrographs of Water Level Elevations for Monitoring Wells

Kirtland AFB presumably caused by groundwater pumping from the Albuquerque and Kirtland AFB well fields. As discussed in Section 2.3, the Albuquerque and Kirtland AFB production wells are located near the northern boundary of Kirtland AFB.

Rift-related faults along the west front of the Manzano and Manzanita Mountains may impact the movement of groundwater onto the site but the effects of these faults is presently unknown. The faults bounding the west side of the Manzano and Manzanita Mountains (Figure 1) create a complex subsurface environment with bedrock and alluvial fill juxtaposed along fault boundaries. The relationship of these faults with groundwater occurrence is currently being studied by the SNL Site-Wide Hydrogeologic Characterization (SWHC) Project.

3.5 Fate and Transport of Chemicals of Concern

The Phase I EBS report (LATA, 1993, Appendix C) presents an overview of some of the chemical, physical, and biological processes that may affect the fate and transport of chemicals in water, soil, and air. The processes are discussed briefly here for the chemicals of concern. Chemical processes may include solubilization, hydrolysis, oxidation, and photolysis. Physical processes may include advection and hydrodynamic dispersion, volatilization, and sorption/desorption to solid surfaces. Biological processes include biodegradation, bioaccumulation, and bioconcentration. The significance of any or all of these processes depends upon the physical and chemical properties of the chemicals in question, the physical and chemical properties of the soil and pore water, and environmental factors such as temperature, humidity, precipitation, water recharge and air movement. The combination of these processes results in a time-dependent reduction of chemical concentrations in water, soil, and air. This reduction is often expressed as first-order decay rate. The complex reactions which occur in the environment affect the mobility and persistency of the chemical.

The solubility of a chemical in water is an important indicator of its relative mobility in the environment. Solubility is both a function of the properties of the contaminant and a function of the solvent (temperature, ionic strength, dissolved organic carbon content, redox potential, and pH). The lower the aqueous solubility of the contaminant, the less likely it will be present in water moving through the vadose zone. PETN and RDX are very low aqueous solubilities of less than one part per million. TNT and most of the other organic compounds have low potential solubility in low ionic strength waters such as meteoric water. A high percent of dissolved organic carbon in water can substantially raise the solubility of an organic compound. Because the organic carbon content of the soils at McCormick Ranch is probably very low, as is typical of soils in an arid environment, the solubility of the organic chemicals of concern would not be adversely increased at the site.

The solubility of metals varies with the specific compound of the metal and also depends upon the salinity, redox, and pH of the pore water. In general, more alkaline pore waters (> pH 7), such as typical of semi-arid and arid environments, would tend to reduce the solubility of most metals.

The mobility of a chemical is greatly enhanced once it has been dissolved in water. However, other processes may occur that decrease its mobility. Sorption and precipitation are recognized as important processes for inhibiting the migration of some compounds. As discussed in the Phase I EBS report, sorption is a function of several properties of the contaminants, the soil, and the pore water. The partitioning of chemicals between water and soil has been explored in several ways in an attempt to predict the tendency of a chemical to sorb to a solid surface. Organic compounds with low water solubilities tend to partition strongly onto soils.

Two other chemical processes important for the degradation of organic compounds are hydrolysis and oxidation/reduction. The rates at which organic compounds are degraded by these two processes varies widely. Hydrophilic compounds tend to hydrolyze more rapidly than hydrophobic compounds. Microorganisms are often responsible for enzymatically enhancing hydrolysis and oxidation/reduction processes.

Of the chemicals of concern at McCormick Ranch, the organic compounds such as PETN and TNT are not highly soluble in water. Their mobility is limited by their low solubilities and tendency to sorb to soil particles. It is likely that organic compounds such as PETN and TNT, if present, have degraded in the surface and subsurface soils due to chemical and biological reactions. Metals of concern, such as lead, are usually strongly sorbed to soil particles under alkaline conditions such as at McCormick Ranch. Therefore, migration of dissolved metals in water, if present, would not be likely at the site. Ammonium nitrate and potassium nitrate are soluble. Nitrate, a negatively charged molecule, would not be strongly sorbed to soil particles and would tend to migrate as a solute in water. Because most water at McCormick Ranch evaporates on the ground surface or in the shallow subsurface before it can infiltrate to groundwater, nitrate compounds, if present, would precipitate as water evaporates. This precipitation would result in the accumulation of previously dissolved species such as nitrates, sulfates, carbonates, and chlorides within a zone of evapotransporation. The caliche encountered at depths of several feet below ground surface is the result of similar precipitation.

The Environmental Restoration (ER) Program and Site-Wide Hydrogeologic Characterization (SWHC) Project for Sandia National Laboratories (SNL) are currently assessing the potential for aqueous phase contaminant transport from the surface and near-surface sources through the vadose zone under ambient flow conditions at SNL/Kirtland AFB. Although these studies are preliminary and are not specific to McCormick Ranch, the approach by SNL for estimating contaminant transport is useful and should be considered for future work at McCormick Ranch. Using an analytical solution to the one-dimensional advection-dispersion equation, solute concentrations were predicted by SNL in space and time under a range of conditions expected at Kirtland AFB (SNL, 1993). The concentration at the water table and the contaminant concentration with depth were predicted to a depth of 397 feet (chosen as a typical depth to the water table in the upper unit of the Santa Fe Group west of the fault zones at Kirtland AFB) for a time period of up to 100 years. The range of recharge rates used in the analyses were between 0.001 and 0.1 ft/yr. A range of retardation factors (1 to 100) were used to represent the mobility of potential contaminants. Higher retardation factors represent contaminants which are less mobile.

The results of the analyses indicated that no solute reached the water table even at the longest time period of 100 years and that the maximum depth of contamination was 115 feet for the most conservative cases (retardation factor of 1). More strongly sorbed species (high retardation factor), such as heavy metals and depleted uranium, did not migrate beyond 33 feet in the simulations. The recharge rate and the site-specific retardation factor appear to be the most important parameters in assessing the transport of solutes through the vadose zone. Analyses of all the contaminants of concern at McCormick Ranch were not performed in the SNL study and retardation factors were not found in the literature. However, based on their low solubilities, the organic chemicals such as PETN, TNT, and SVOCs are expected to have high retardation factors. Nitrate is expected to have a low retardation factor and would represent the most conservative case for migration (worst case scenario).

While the work described above does not factor in the complexities of transport through the vadose zone or site-specific factors at the McCormick Ranch site, it does indicate that within the time frame of the activities at the site (approximately 50 years) it is extremely unlikely that any contaminants have been transported to the water table from near the ground surface.

The DIP 5 Test (Figure 2.1 of Phase II EBS Report) is the only deep subsurface test at the site that may have introduced contamination into a deeper portion of the vadose zone (approximately 300 feet below ground surface). According to available records on the test, the explosives were flushed out of their casings after it was determined that detonation could not be successfully accomplished. After the original explosives were flushed out, then the holes were filled with a different mixture and the detonations were completed. Subsequent studies indicated that these detonations had been accomplished successfully. Contaminants from the DIP-5 test could be present on the ground surface where the original explosives were flushed and directly below the bottom of the borehole casing where the original explosives may have been forced downward during flushing. Further study may be necessary to determine the effects of the Dip-5 test on the groundwater.

4.0 CONCLUSIONS

Groundwater beneath the McCormick Ranch site is greater than 350 feet below ground surface. The aquifer at this depth is in the upper unit of the Santa Fe Group, consisting primarily of sands and gravels. The groundwater flow direction is to the north northwest. Water levels in the Kirtland AFB area are declining at a rate of approximately 0.5 to 2 feet per year presumably due to pumping from water supply wells in Albuquerque and Kirtland AFB. Water level declines at McCormick Ranch have an average of 1.8 ft/yr since 1992.

The results of the Phase II EBS indicate that surface contamination from testing activities does not appear to be significant. However, even if soil contamination at the ground surface has occurred, the potential for migration to groundwater is low. Most of the contaminants of concern have low aqueous solubilities (high retardation factors) and are subject to physical and biological degradation. In addition, evapotranspiration greatly exceeds precipitation in the region. The recharge rate at the nearby CWL is estimated to be only $1x10^{-3}$ ft/yr. Because of the low recharge rate and low mobility of most of the contaminants of concern, the potential for contaminants to migrate to groundwater via solute transport is expected to be low at McCormick Ranch. Even contaminants with low retardation factors (high mobility), such as nitrate, would not be expected to migrate quickly because of the low recharge rate. Only one test, DIP 5, involved explosive testing at depths greater than 50 feet below ground surface. There is not sufficient data available to determine whether hazardous materials are present in the subsurface at the total depth of the DIP 5 test. None of the monitoring wells at McCormick Ranch are located immediately downgradient of the DIP 5 test location and are not useful for detection of groundwater contamination from this test.

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ATTACHMENT 2

Field Screening and Analytical Laboratory QA/QC

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1.0 FIELD SCREENING QA/QC REQUIREMENTS

The Final Quality Assurance Project Plan (GRAM 1994b) required the following QA/QC checks during all field screening activities:

- **Laboratory Standard Samples**:

  TNT: One TNT standard was analyzed before analyzing each batch of environmental samples.

  PETN and SVOCs: Two PETN (800 and 1,000 ppm) and two diesel (100 and 500 ppm) standards were analyzed with each batch of samples (i.e., each plate).

  NITRATE: Three nitrate standards were analyzed before each batch of soil samples. Results of the standard analyses were averaged.

- **Duplicate Samples**: Duplicate samples were analyzed at a frequency of one per 20 soil samples analyzed for all field screening procedures, except for radiation (α, β, γ) screening. A total of 16 duplicate soil samples were analyzed for each field screening procedure.

- **Method Blanks**: Method blanks were analyzed at a frequency of one per 20 soil samples analyzed for all field screening procedures, except for radiation (α, β, γ) screening. Method blanks are blank samples (e.g., water, hexane) that are prepared using the same equipment and decontamination procedures used to analyze environmental samples. A total of 16 method blanks were analyzed for each field screening procedure.

- **Matrix Spike Samples**: Matrix spike samples were analyzed at a frequency of one per 20 soil samples analyzed by the TLC (PETN and SVOCs). A matrix spike is a sample in which a known amount of analyte (e.g., PETN, diesel) is added to a soil sample during extraction. A total of 16 matrix spike samples were screened for PETN and SVOCs.

- **Soil Blank Sample**: Soil blank samples were analyzed for TNT, PETN and SVOCs at a frequency of 1 per 40 soil samples screened. Soil blank samples were collected in an area approximately one-half mile west of the site containing similar soils to those sampled, where no explosive testing is known to have occurred. The purpose of the soil blank samples was to detect false positive results that may occur as a result of interferences related to soil composition (e.g., presence of humic materials). A total of eight soil blank samples were analyzed for both the TLC (PETN and SVOC) and TNT field screening procedures.

- **Blank Spike Sample**: Blank spike samples were tested at a frequency of one per 20 soil samples tested for PETN and SVOCs by the TLC method. A blank spike is a spiked sample which is prepared in the same manner as a matrix spike sample, except that no soil is added to the sample being analyzed. A total of 16 blank spike samples were analyzed for PETN and SVOCs using the TLC method.

2.0 RESULTS OF QA/QC FIELD SCREENING

- **<u>Duplicate Samples</u>**: As defined in Final Quality Assurance Project Plan (GRAM 1994f), precision is used to describe the reproducibility of results and is expressed during the data validation process as the relative percent difference (RPD) between analytical results for sample duplicates. Duplicate samples comprise at least 10 percent of the samples screened for TNT, PETN, nitrates, and SVOCs. The acceptable RPD range used for the evaluation of duplicate soil samples screened for TNT and nitrates was +/- 200 percent, as defined in the Final Quality Assurance Project Plan (GRAM 1994f) for laboratory analysis of soil samples.

  Sixteen duplicate samples were screened for TNT, PETN, nitrates and SVOCs during the field activities. The duplicate samples screened for TNT and nitrates were reviewed to examine sample analytical precision (Table 1). The nominal accuracy acceptability criteria (+/- 200 percent) were applied to the data results. For the duplicate soil samples collected and screened for nitrate, none of the samples violated the acceptable limits. Samples screened for TNT were all below the MDL, and the evaluation of precision, therefore, can not be rigorously applied.

  RPD values could not be calculated for the TLC method as it is a qualitative analysis. Therefore, the acceptance criteria used for the TLC method was one in which the duplicate sample spot was comparable to the sample spot for reproducibility in shape and spot intensity. All duplicate samples analyzed by the TLC method were reproducible.

- <u>Matrix Spike Samples</u>: Matrix spike samples were analyzed for PETN and SVOCs using the TLC method. They were prepared using approximately 5 grams of soil sample in hexane and 50 microliters (uL) of 100,000 ppm diesel standard and 4,000 ppm of PETN standard. However, because the TLC method is a qualitative procedure percent recovery values were not used for data evaluation. The PETN and diesel standards in the MS samples allowed for a direct comparison between the sample results and a positive PETN and hydrocarbon results in any samples screened. Sixteen matrix spike samples were analyzed for PETN and SVOCs during the field screening activities. Positive indications for hydrocarbons (i.e., PETN and diesel) were detected in all 16 matrix spike samples screened.

Table 1 Summary of Duplicate Analyses for Nitrates and TNT

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN AND SVOCs
KRLTD154-0020	16	09/15/94	3	ND	-
KRLTD154-0020 DUP.	16	09/15/94	3	ND	-
RPD			0	0	NA
KRLTD154-0040	17	09/16/94	ND	ND	-
KRLTD154-0040 DUP.	17	09/16/94	ND	ND	-
RPD			0	0	NA
KRLTD154-0060	14	09/13/94	3	ND	+
KRLTD154-0060 DUP.	14	09/13/94	3	ND	+
RPD			0	0	NA
KRLTD154-0080	15	09/14/94	5	ND	-
KRLTD154-0080 DUP.	15	09/14/94	5	ND	-
RPD			0	0	NA
KRLTD154-0100	12	09/12/94	3	ND	-
KRLTD154-0100 DUP.	12	09/12/94	4	ND	-
RPD			28	0	NA
KRLTD154-0120	13	09/13/94	8	ND	-
KRLTD154-0120 DUP.	13	09/13/94	6	ND	-
RPD			28	0	NA
KRLTD154-0140	17	09/16/94	4	ND	-
KRLTD154-0140 DUP.	17	09/16/94	4	ND	-
RPD			0	0	NA

Table 1 Summary of Duplicate Analyses for Nitrates and TNT (continued)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN AND SVOCs
KRLTD154-0160	4	08/29/94	3	ND	-
KRLTD154-0160 DUP.	4	08/29/94	5	ND	-
RPD			50	0	NA
KRLTD154-0180	10	09/08/94	12	ND	-
KRLTD154-0180 DUP.	10	09/08/94	11	ND	-
RPD			9	0	NA
KRLTD154-0200	11	09/09/94	1	ND	-
KRLTD154-0200 DUP.	11	09/09/94	1	ND	-
RPD			0	0	NA
KRLTD154-0220	19	09/20/94	ND	ND	-
KRLTD154-0220 DUP.	19	09/20/94	1	ND	-
RPD			0	0	NA
KRLTD154-0240	7	09/01/94	4	ND	-
KRLTD154-0240 DUP.	7	09/01/94	2	ND	-
RPD			66	0	NA
KRLTD154-0260	8	09/02/94	ND	ND	-
KRLTD154-0260 DUP.	8	09/02/94	ND	ND	-
RPD			0	0	NA
KRLTD154-0280	2	08/25/94	1	ND	-
KRLTD154-0280 DUP.	2	08/25/94	NA	NA	-
RPD			NA	NA	NA

Table 1 Summary of Duplicate Analyses for Nitrates and TNT (concluded)

SITE ID NUMBER	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	PETN AND SVOCs
KRLTD154-0300	9	09/06/94	2	ND	-
KRLTD154-0300 DUP.	9	09/06/94	ND	ND	-
RPD			100	0	NA

ND = Not Detected, Below Method Detection Limit

NA = Not Applicable

"+" = PETN and/or SVOCs detected

"-" = PETN and/or SVOCs not detected

- **Method Blank Samples**: Method blank samples are used to monitor the instruments used for screening for interferences and contamination from glassware, reagents, and laboratory equipment during the field screening process. Method blanks were prepared and analyzed using the same equipment and procedures as soil samples. Sixteen method blank samples were prepared and analyzed for each of the nitrate, TNT, and TLC (PETN and SVOCs) screening procedures. No indication of cross-contamination or interference was noted in any of the method blanks. Results of method blanks for field screening are presented in Table 2.

- **Soil Blank Samples**: Soil blank samples were prepared using soil collected in an area approximately one-half mile west of the site containing similar soils to those sampled, where no explosives testing is known to have occurred. The purpose of the soil blank analyses was to detect false positive results that may occur due to interferences related to soil composition (e.g., presence of humic materials). No indication of contamination was detected in the soil blank samples.

- **Blank Spike Samples**: Blank spike samples were analyzed for PETN and SVOCs using the TLC method. Blank spike samples were prepared using 50 uL of 100,000 ppm diesel standard and 4,000 ppm PETN standard in 4 milliliters (mL) of hexane. However, because the TLC method is a qualitative procedure, percent recovery values could not be calculated. The PETN and diesel standards in the hexane ensured that the method was detecting contamination in the absence of any interference from the soil material. Sixteen blank spike samples were analyzed for PETN and SVOCs during the field screening activities, and indications of hydrocarbons were detected in all blank spike samples screened.

Table 2 Summary of Field Screening Blank QC Sample Analyses

QC SAMPLE	BATCH NUMBER	DATE SCREENED	NITRATES (PPM)	TNT (PPM)	HYDROCARBONS
Method Blank	16	09/15/94	ND	ND	-
Method Blank	17	09/16/94	ND	ND	-
Soil Blank	17	09/16/94	NA	ND	-
Method Blank	13	09/13/94	ND	ND	-
Method Blank	15	09/14/94	ND	ND	-
Soil Blank	15	09/14/94	NA	ND	-
Method Blank	12	09/12/94	ND	ND	-
Method Blank	13	09/13/94	ND	ND	-
Soil Blank	13	09/13/94	NA	ND	-
Method Blank	17	09/16/94	ND	ND	-
Method Blank	4	08/29/94	ND	ND	-
Soil Blank	4	08/29/94	NA	ND	-
Method Blank	10	09/08/94	ND	ND	-
Method Blank	11	09/09/94	ND	ND	-
Soil Blank	11	09/09/94	NA	ND	-
Method Blank	19	09/20/94	ND	ND	-
Method Blank	7	09/01/94	ND	ND	-
Soil Blank	7	09/01/94	NA	ND	-
Method Blank	8	09/02/94	ND	ND	-
Method Blank	2	08/25/94	NA	NA	-
Method Blank	9	09/06/94	ND	ND	-
Soil Blank	9	09/06/94	NA	ND	-
Method Blank	5	08/30/94	ND	ND	-
Soil Blank	5	08/30/94	NA	ND	-

NA = Not Analyzed ND - Not Detected. - = Hydrocarbons Not Detected

3.0 LABORATORY QA/QC REQUIREMENTS

The following sections describe QA/QC requirements and procedures used to ensure valid data from the analytical laboratory.

- **Duplicate Samples**: Duplicate samples are used to assess precision, and were collected at a frequency of 1 sample per 10 soil samples sent to the laboratory for analysis.

- **Matrix Spikes and Matrix Spike Duplicate Samples**: Matrix Spike/Matrix Spike Duplicates (MS/MSD) samples were submitted at a frequency of one MS/MSD for every 20 soil samples submitted. Each MS/MSD was collected by splitting the soil sample that was collected after it had been homogenized in a stainless steel bowl. The splitting of the samples was performed in the field screening laboratory. Samples to be analyzed as MS/MSD were identified on the laboratory Chain-of Custody forms.

- **Equipment Blanks**: Equipment blanks were collected at a frequency of 1 sample per 10 soil samples sent to the laboratory for analysis. Because 40 on-site soil samples were sent to the laboratory for analysis, four equipment blanks were collected. Equipment blanks were collected from the following:
    - Backhoe bucket;
    - Hand auger bit;
    - Soil scoop; and
    - Stainless steel bowl.

The IRP guidelines specify that one equipment blank will be collected each day for each sampling team (USAF, 1993). However, because of the large number of samples collected for field screening compared to the small number of laboratory analyses, it was determined that four representative equipment blanks would be more appropriate.

Equipment blanks were collected by pouring organic-free ASTM Type II water, supplied by Quanterra Analytical Services, over a decontaminated piece of sampling equipment and then into sample containers. The water was not filtered prior to being collected in the sample containers.

- **Ambient Blank**: One ambient blank was collected to determine: (1) Presence of any airborne contamination, (2) Cleanliness of the bottles, and (3) Purity of the ASTM Type II water. The water was poured directly from the water containers into the sample containers. The water was not filtered prior to being poured into the sample containers.

- **Holding Times**: Maximum allowable holding times, obtained from the AFCEE IRP Handbook (USAF, 1993), are summarized in Table 3.

Table 3 Maximum Allowable Holding Times

ANALYTE	METHOD	MAXIMUM HOLDING TIME (days)*	
		SOIL	WATER
Explosives	SW8330	14/40	7/40
Explosives	SW8321	14/40	7/40
Nitrate + Nitrite	E353.2	28	28
Semi-VOCs	SW8270	14/40	7/40
ICP Metals	SW6010	180	180
Mercury	SW7471	28	28
Lead Arsenic Selenium Thallium	SW7421 SW7060 SW7740 SW7841	180	180
Cyanide	SW9012M	14	14

* Extraction/Analysis

- **Sample Preservation**: Sample preservation methods, obtained from the AFCEE IRP Handbook (USAF, 1993), are summarized in Table 4 for soil samples and Table 5 for water samples. All samples were stored in a cooler with blue ice after being collected in the field. Water samples were collected in pre-preserved bottles provided by the analytical laboratory. The samples were stored in a dedicated refrigerator at 4 °C when they were transferred to the field screening laboratory. The temperature of the refrigerator was recorded on a daily basis in the laboratory log book. The samples were shipped to the analytical laboratory in coolers with temperature blanks and ice. The temperature of all coolers was recorded when the samples were received at the analytical laboratory. The GRAM project manager was notified when cooler temperatures exceeded allowable limits. The temperature of all samples was within allowable limits when received by the analytical laboratory except for a cooler with sample 0266-0001 and 0296-0001, shipped on September 6, 1994. No analyses were performed on these samples, and the two locations were resampled.

- **Chain-of-Custody**: The Chain-of-Custody was maintained for all samples. Custody of all samples was transferred from the sampling team to the field screening laboratory on a daily basis using Field Soil Sample Identification/Custody Form (Appendix E). Custody of samples selected for laboratory analysis was transferred to the analytical laboratory using the Chain-of -Custody form (Appendix G). Custody was recorded from the field screening laboratory through the shipping company to the analytical laboratory. Sample containers and coolers used to send samples to the analytical laboratory were sealed using custody seals.

3.1 Laboratory Control Samples

Analysis of Laboratory Control Samples (LCS) was conducted for each batch of samples submitted for analysis. LCSs are well characterized, laboratory generated samples used to monitor the day-to-day performance of routine analytical methods in a laboratory. The results of the LCS Analyses were compared to well-defined laboratory acceptance criteria to determine whether the laboratory system was "in control". Three types of LCSs were analyzed: Duplicate Control Samples (DCS), Single Control Samples (SCS), and Method Blanks. Each of the these LCS type is described below.

- **Duplicate Control Samples**: A DCS is a well-characterized matrix (blank water, sand, sodium sulfate, or celite) which is spiked with certain target parameters and analyzed at approximately 10% of the sample load in order to establish method-specific control limits. Specific compounds used for DCS spikes are the same as for MS/MSDs. A DCS is used when a MS/MSD is not run during a batch.

Table 4. Analytical Methods, Containers, Volumes and Preservation Methods for Soil Samples

PARAMETER	ANALYTICAL METHOD	NUMBER OF CONTAINERS	TYPE OF CONTAINER	WEIGHT PER ANALYSES	PRESERVATION METHOD
Explosives	SW8330 SW8321	1	amber glass	50g	4°C
Nitrate + Nitrite	E353.2	1	clear glass	50g	4°C
Semi-VOCs	SW8270	1	amber glass	50g	4°C
ICP Metals	SW6010	1	clear glass	10g	4°C
Mercury	SW7471	1	clear glass	10g	4°C
Lead Arsenic Selenium Thallium	SW7421 SW7060 SW7740 SW7841	1	clear glass	10g	4°C
Cyanide	SW9012M	1	clear glass	50g	4°C

NOTE:

(1) For each sample collected, one 16-oz glass jar will be filled to provide sufficient sample weight for all required analysis.

(2) Sample bottles will be certified pre-cleaned to meet EPA requirements, and will be provided by the analytical laboratory.

Table 5. Analytical Methods, Containers, Volumes and Preservation Methods for Water Samples

PARAMETER	ANALYTICAL METHOD	NUMBER OF CONTAINERS	TYPE OF CONTAINER	VOLUME PER CONTAINER	PRESERVATION METHOD
Explosives	SW8330 SW8321	2	amber glass	1000ml	$4^{O}C$
Nitrate + Nitrite	E353.2	1	polyethylene	250ml	$4^{O}C$ H_2SO_4 to pH <2
Semi-VOCs	SW8270	2	amber glass	1000ml	$4^{O}C$
ICP Metals	SW6010	1	polyethylene	500ml	$4^{O}C$ HNO_3 to pH <2
Mercury	SW7471	1	amber glass	250ml	$4^{O}C$ HNO_3 to pH <2
Lead Arsenic Selenium Thallium	SW7421 SW7060 SW7740 SW7841	1	polyethylene	500ml	$4^{O}C$ HNO_3 to pH <2
Cyanide	SW9012M	1	polyethylene	500ml	$4^{O}C$ NaOH to pH < 12

NOTE: Sample bottles will be certified pre-cleaned to meet EPA requirements, and will be provided by the analytical laboratory.

- **Single Control Samples**: A SCS consists of a control matrix that is spiked with surrogate compounds appropriate to the method being used. In cases where no surrogate was available, (e.g. metals or conventional analyses) a single control sample identical to the DCS served as the control sample. An SCS is prepared for each sample lot. Accuracy is calculated identically to the DCS.

- **Method Blank**. A method blank is a laboratory-generated sample which assesses the degree to which laboratory operations and procedures cause false-positive analytical results for the samples. Results from the analysis of blanks were assessed to determine sources of contamination and the impact of contamination on the analytical results for soil samples. A method blank comes into contact with all equipment used to prepare soil samples, and is run with each batch of samples for each method.

4.0 LABORATORY QA/QC RESULTS

With the exception of duplicate samples, all analytical data were evaluated by the Quanterra Laboratory QA Officer. The following sections discuss the results of duplicate sample analyses, and the results of the Quanterra Laboratory data evaluations.

- Duplicate Samples: A summary of RPD values for metals and nitrate + nitrite, and their acceptability is provided in Table 6. All duplicate sample results were within the allowable limit (i.e., RPD < 200, as presented in the Final Quality Assurance Project Plan (GRAM 1994f).

4.1 Analytical Data Evaluation

The following section presents the case narratives for the QC samples analyzed at Quanterra Laboratory. A summary of QC lot numbers and QC run numbers is presented in Table 7. The case narratives were provided by the Quanterra Laboratory QA Officer, and are attached in their original form. Although some QC parameters were out of control limits, the data presented in the Phase II EBS Report have been evaluated and qualified (where appropriate). These data provide an accurate representation of contaminant concentrations in the soil samples analyzed by Quanterra Laboratories.

Review of QC data from Quanterra Laboratories identified the following two types of "out-of-control" situations:

- surrogate compound, MS/MSD, and LCS recoveries were above acceptable limits in several analyses. However, none of the compounds that were above the control limits in the QC samples were detected in any of the soil samples from McCormick Ranch. Recoveries above the control limits indicate that analyte quantitation may be biased toward higher values. This is not a problem when the compounds that exceed recovery limits are not detected in the samples.

- A method blank analyzed for metals by ICP was found to contain 5.8 mg/kg of iron, and one of the equipment blanks was determined to contain 0.84 mg/kg of calcium and 0.4 mg/kg of iron. Iron concentrations in the soil samples collected at McCormick Ranch ranged from 5,280 to 30,300 mg/kg, and calcium concentrations ranged from 14,300 to 142,000 mg/kg. These values are 3 to 6 orders of magnitude larger than the concentrations in the blanks; and, therefore, the effect of these metals on analyte quantitation in the blank samples was negligible.

The above "out-of-control" situations were documented by the Quanterra Laboratory Technician and QA Officer, and do not have a negative impact on the data that are reported. The analytical data presented in the Phase II EBS Report accurately reflect the presence and concentrations of contaminants in the soil samples collected at McCormick Ranch.

Table 6. Summary of Duplicate Sample Results

SAMPLE NUMBER	ANALYTE	FIRST RESULT (mg/kg)	SECOND RESULT (mg/kg)	RPD	LIMIT
0047	Aluminum	11600	8710	28	200
	Arsenic	7.2	5.5	27	200
	Barium	130	115	12	200
	Calcium	14300	14500	1	200
	Chromium	19.5	17.3	12	200
	Cobalt	7.1	6.7	6	200
	Copper	208	1520	152	200
	Iron	30300	27300	10	200
	Lead	20.4	20.5	0	200
	Magnesium	3880	3280	17	200
	Manganese	445	420	6	200
	Nickel	19.3	17.1	12	200
	Potassium	3210	2530	24	200
	Vanadium	17.1	15.2	12	200
	Zinc	107	100	7	200
	Nitrate + Nitrite (as N)	5.6	6.3	12	200
0084	Aluminum	11700	12900	10	200
	Arsenic	4.6	4.4	4	200
	Barium	125	131	5	200
	Calcium	43700	44500	2	200
	Chromium	10.5	11.4	8	200
	Copper	6.5	6.5	0	200
	Iron	10900	11500	5	200
	Lead	8.6	8.2	5	200

Table 6. Summary of Duplicate Sample Results (continued)

SAMPLE NUMBER	ANALYTE	FIRST RESULT (mg/kg)	SECOND RESULT (mg/kg)	RPD*	LIMIT
0084 (cont.)	Magnesium	3790	4040	6	200
	Manganese	190	200	5	200
	Potassium	2010	2240	11	200
	Vanadium	20.9	22.9	9	200
	Zinc	29	30.3	4	200
	Nitrate + Nitrite (as N)	95.4	87.4	9	200
0179	Aluminum	10700	9090	16	200
	Arsenic	2.5	2.6	4	200
	Barium	113	107	5	200
	Calcium	31000	27000	14	200
	Chromium	8.6	7.9	8	200
	Copper	6.4	6.5	2	200
	Iron	9300	8580	8	200
	Lead	6.3	6.3	0	200
	Magnesium	3030	2750	10	200
	Manganese	134	126	6	200
	Potassium	1970	1700	15	200
	Vanadium	17.1	15.2	12	200
	Zinc	23.2	21.6	7	200
	Nitrate + Nitrite (as N)	5.6	3.5	46	200
0231	Aluminum	8970	8280	8	200
	Arsenic	2.5	2.5	0	200
	Barium	163	142	14	200

Table 6. Summary of Duplicate Sample Results (concluded)

SAMPLE NUMBER	ANALYTE	FIRST RESULT (mg/kg)	SECOND RESULT (mg/kg)	RPD	LIMIT
0231 (cont.)	Calcium	48000	42100	13	200
	Chromium	9.2	8.3	10	200
	Copper	7.4	7.2	3	200
	Iron	9150	8620	6	200
	Lead	6.8	6.9	1	200
	Magnesium	3860	3640	6	200
	Manganese	195	192	2	200
	Potassium	2600	2390	8	200
	Selenium	ND*	0.69	94	200
	Vanadium	15.6	15.2	3	200
	Zinc	26.2	26.1	0	200
	Nitrate + Nitrite (as N)	5.5	5.4	2	200

* The value used to calculate RPD was 0.25 mg/kg, 1/2 of the PQL.

Table 7. Summary of QC Lot Number and QC Run Number

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
276-0001	SOIL	SW8321	02 SEP 94-7B	02 SEP 94-7B
284-0001				
081-0001				
084-0001				
084-0002				
151-0001				
157-0001				
160-0001				
161-0001				
165-0001				
276-0001	SOIL	SW8330	02 SEP 94-7B	02 SEP 94-7B
284-0001				
081-0001				
084-0001				
084-0002				
151-0001				
157-0001				
160-0001				
161-0001				
165-0001				
157-0001	SOIL	SW8270	07 SEP 94-11A	07 SEP 94-11A
165-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
276-0001	SOIL	SW7471	07 SEP 94-C	07 SEP 94-C
284-0001				
081-0001				
084-0001				
084-0002				
276-0001	SOIL	SW7421 SW7060 SW7740	02 SEP 94-TX	02 SEP 94-TX
284-0001				
081-0001				
084-0001				
084-0002				
276-0001	SOIL	SW6010	02 SEP 94-T	02 SEP 94-T
284-0001				
081-0001				
084-0001				
084-0002				
276-0001	SOIL	E353.2	16 SEP 94-A	16 SEP 94-A
284-0001				
081-0001				
084-0001				
084-0002				
151-0001				
157-0001				
160-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
161-0001	SOIL	E353.2	16 SEP 94-A	16 SEP 94-A
165-0001				
276-0001	SOIL	SW9012M	07 SEP 94-A	07 SEP 94-A
284-0001				
081-0001				
084-0001				
084-0002				
151-0001				
157-0001				
160-0001				
161-0001				
165-0001				
301-0001	SOIL	SW8321	09 SEP 94-7B	09 SEP 94-7B
307-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				
254-0001				
255-0001				
258-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
301-0001	SOIL	SW8330	09 SEP 94-7A	09 SEP 94-7A
307-0001				
231-0001				
231-0002				
238-0002				
288-0001				
292-0001				
254-0001				
255-0001				
258-0001				
307-0001	SOIL	SW8270	08 SEP 94-11A	08 SEP 94-11A
271-0001				
273-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				
254-0001				
255-0001				
258-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
301-0001	SOIL	SW7471	12 SEP 94-E	12 SEP 94-E
307-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				
254-0001				
255-0001				
258-0001				
247-0001				
246-0001				
248-0001				
250-0001				
249-0001				
301-0001	SOIL	SW7421 SW7060 SW7740	12 SEP 94-DX	12 SEP 94-DX
307-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
254-0001	SOIL	SW7421 SW7060 SW7740	12 SEP 94-DX	12 SEP 94-DX
255-0001				
258-0001				
247-0001				
246-0001				
248-0001				
250-0001				
249-0001				
301-0001	SOIL	SW6010	13 SEP 94-A	13 SEP 94-A
307-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				
254-0001				
255-0001				
258-0001				
247-0001				
246-0001				
248-0001				
250-0001				
249-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
301-0001	SOIL	SW7841	10 SEP 94-B	10 SEP 94-B
307-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				
254-0001				
255-0001				
258-0001				
247-0001				
246-0001				
248-0001				
250-0001				
249-0001				
301-0001	SOIL	E353.2	16 SEP 94-B	16 SEP 94-B
307-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				
254-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
255-0001				
258-0001				
301-0001	SOIL	SW9012M	12 SEP 94-A	12 SEP 94-A
307-0001				
231-0001				
231-0002				
238-0001				
288-0001				
292-0001				
254-0001				
255-0001				
258-0001				
166-1001	AQUEOUS	SW8321	13 SEP 94-7A	13 SEP 94-7A
246-1001				
246-2001				
247-1001				
248-1001				
166-1001	AQUEOUS	SW8330	13 SEP 94-7A	13 SEP 94-7A
246-1001				
246-2001				
247-1001				
248-1001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
166-1001	AQUEOUS	SW8270	14 SEP 94-11A	14 SEP 94-11A
246-1001				
246-2001				
247-1001				
248-1001				
166-1001	AQUEOUS	SW7470	12 SEP 94-BX	12 SEP 94-BX
246-1001				
246-2001				
247-1001				
248-1001				
166-1001	AQUEOUS	SW7421 SW7060 SW7740 SW7841	16 SEP 94-U	16 SEP 94-U
246-1001				
246-2001				
247-1001				
248-1001				
166-1001	AQUEOUS	SW6010	13 SEP 94-U	13 SEP 94-U
246-1001				
246-2001				
247-1001				
248-1001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
166-1001	AQUEOUS	E353.2	09 SEP 94-A	09 SEP 94-A
246-1001				
246-2001				
247-1001				
248-1001				
166-1001	AQUEOUS	SW9012M	13 SEP 94-L	13 SEP 94-L
246-1001				
246-2001				
247-1001				
248-1001				
178-0001	SOIL	SW8321	19 SEP 94-7B	19 SEP 94-7B
179-0001				
179-0002				
180-0001				
193-0001				
097-0001				
109-0001				
266-0001				
296-0001				
113-0001				
120-0001				
314-0001	AQUEOUS	SW8321	27 SEP 94-7B	27 SEP 94-7B

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
178-0001	SOIL	SW8330	19 SEP 94-7A	19 SEP 94-7A
179-0001				
179-0002				
180-0001				
193-0001				
097-0001				
109-0001				
266-0001				
296-0001				
113-0001				
120-0001				
314-0001	AQUEOUS	SW8330	19 SEP 94-7A	19 SEP 94-7A
179-0001	SOIL	SW8270	21 SEP 94-11A	21 SEP 94-11A
179-0002				
193-0001				
097-0001				
266-0001				
296-0001				
314-0001	AQUEOUS	SW8270	20 SEP 94-11A	20 SEP 94-11A

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
178-0001	SOIL	SW7471	20 SEP 94-AX	20 SEP 94-AX
179-0001				
179-0002				
180-0001				
193-0001				
097-0001				
109-0001				
266-0001				
296-0001				
113-0001				
120-0001				
314-0001	AQUEOUS	SW7470	16 SEP 94-CX	16 SEP 94-CX
178-0001	SOIL	SW7421 SW7060 SW7740 SW7841	22 SEP 94-TX	22 SEP 94-TX
179-0001				
179-0002				
180-0001				
193-0001				
097-0001				
109-0001				
266-0001				
296-0001				
113-0001				
120-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
314-0001	AQUEOUS	SW7421 SW7060 SW7740 SW7841	20 SEP 94-CX	20 SEP 94-CX
178-0001	SOIL	SW6010	22 SEP 94-TX	22 SEP 94-TX
179-0001				
179-0002				
180-0001				
193-0001				
097-0001				
109-0001				
266-0001				
296-0001				
113-0001				
120-0001				
314-0001	AQUEOUS	SW6010	20 SEP 94-CX	20 SEP 94-CX
178-0001	SOIL	E353.2	26 SEP 94-A	26 SEP 94-A
179-0001				
179-0002				
180-0001				
193-0001				
097-0001				
109-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
266-0001				
296-0001				
113-0001				
120-0001				
314-0001	AQUEOUS	E353.2	27 SEP 94-AX	27 SEP 94-AX
178-0001	SOIL	SW9012M	12 SEP 94-A	12 SEP 94-A
179-0001				
179-0002	SOIL	SW9012M	19 SEP 94-A	19 SEP 94-A
180-0001				
193-0001				
097-0001				
109-0001				
266-0001				
296-0001				
113-0001				
120-0001				
314-0001	AQUEOUS	SW9012M	19 SEP 94-A	19 SEP 94-A
046-0001	SOIL	SW8321	23 SEP 94-7C	23 SEP 94-7C
047-0001				
047-0002				
049-0001				
076-0001				
009-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
013-0001				
025-0001				
035-0001				
136-0001				
140-0001				
215-0001				
225-0001				
046-0001	SOIL	SW8330	23 SEP 94-7B	23 SEP 94-7B
047-0001				
047-0002				
049-0001				
076-0001				
009-0001				
013-0001				
025-0001				
035-0001				
136-0001				
140-0001	SOIL	SW8330	23 SEP 94-7B	23 SEP 94-7B
215-0001				
225-0001				
046-0001	SOIL	SW8270	21 SEP 94-11A	21 SEP 94-11A
049-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
046-0001	SOIL	SW7471 SW7421 SW7060 SW7740 SW6010 SW7841	23 SEP 94-BX	23 SEP 94-BX
047-0001				
047-0002				
049-0001				
076-0001				
009-0001				
013-0001				
025-0001				
035-0001				
136-0001				
140-0001				
215-0001				
225-0001				
046-0001	SOIL	E353.2	10 OCT 94-A	10 OCT 94-A
047-0001				
047-0002				
049-0001				
076-0001				

Table 7. Summary of QC Lot Number and QC Run Number (Continued)

SAMPLE NUMBER	QC MATRIX	ANALYTICAL METHOD	QC LOT NUMBER (DCS)	QC RUN NUMBER (SCS/BLANK)
009-0001	SOIL	E353.2	10 OCT 94-A	10 OCT 94-A
013-0001				
025-0001				
035-0001				
136-0001				
140-0001				
215-0001				
225-0001				
046-0001	SOIL	SW9012M	19 SEP 94-A	19 SEP 94-A
047-0001				
047-0002				
049-0001				
076-0001				
009-0001				
013-0001				
025-0001				
035-0001				
136-0002	SOIL	SW9012M	23 SEP 94-A	23 SEP 94-A
140-0001				
215-0001				
225-0001				

CASE NARRATIVE

QUANTERRA PROJECT NUMBER 077428

General Comments

The temperature blank associated with your samples was recorded as 3.5 deg C. The ambient temperature was 5.3 deg C.

Nitroaromatics and Nitramines by HPLC - Method 8330

The matrix spike/matrix spike duplicate has a tetryl recovery above the control limits. The samples were re-injected and the recoveries were confirmed.

Semivolatile Organics - Method 8270

The laboratory control sample has benzoic acid reported as NA. The actual value recovered (43%) is within the control limits. Noted in the QAPjP, this compound is flagged for a variance.

Due to electronic deliverable limitations, the library search data is available in hardcopy format only.

The method blank 2-Fluorobiphenyl surrogate reocvery is above the control limits. Re-injections on different instruments have resulted in similar recoveries. The samples associated with this blank have no positive detections. The initial analysis has been reported.

Metals - Various Methods

The ICAP antimony matrix spike/matrix spike duplicate recoveries are outside of the control limits. Re-analysis of the pair confirm the initial recoveries. The initial analysis was reported.

The matrix spike/matrix spike duplicate for Aluminum, Calcium and Iron have recoveries outside of the control limits due to the element having a sample concentration greater than or equal to 4 times the concentration of the matrix spike.

CASE NARRATIVE - cont.

QUANTERRA PROJECT NUMBER 077428

Metals - Various Methods cont.

The thallium matrix spike/matrix spike duplicate have recoveries below the control limits. The re-analysis yielded recoveries within the control limits. The re-analysis was reported.

Analysis for thallium was performed by graphite furnace in order to achieve detection levels required by the QAPjP.

Inorganics - Various Methods

The Nitrate plus Nitrite laboratory control sample was mis-spiked at 12.5 mg/Kg due to a misinterpretation of the QAPjP.

The matrix spike/matrix spike duplicate recoveries were not calculated due to the sample value being 4 times the concentration of the matrix spike.

There were no other anomalies associated with this report.

CASE NARRATIVE

QUANTERRA PROJECT NUMBER 077507

General Comments

The temperature blanks associated with your samples were recorded as 1.8 deg C and 9.8 deg C. The ambient temperatures were 3.2 deg C and 9.4 deg C. The samples (02660001 and 02960001) associated with the temperature of 9.8 deg C were canceled per your instructions.

Semivolatile Organics - Method 8270

Sample 02540001 matrix spike duplicate (Quanterra ID 077507-0010SD) has a Terphenyl-d14 surrogate recovery above the control limits. A re-injection of this sample confirmed the recovery. The initial injection was reported.

The matrix spike/matrix spike duplicate had several recoveries above the control limits. The samples were re-injected and the recoveries were confirmed. The initial injection was reported.

The laboratory control sample has benzoic acid reported as NA. The actual value recovered (43%) is within the control limits. Noted in the QAPjP, this compound is flagged for a variance.

Due to electronic deliverable limitations, the library search data is available in hardcopy format only.

Metals - Various Methods

The ICAP matrix spike/matrix spike duplicate for iron and manganese have %RPDs above control limits and antimony, barium and manganese recoveries outside of the control limits. Re-analysis of the pair confirm the initial recoveries and %RPDs. The initial analysis was reported.

The matrix spike/matrix spike duplicate for Aluminum, Calcium and Iron have recoveries outside of the control limits due to the element having a sample concentration greater than or equal to 4 times the concentration of the matrix spike.

CASE NARRATIVE - cont.

QUANTERRA PROJECT NUMBER 077507

Selected Metals - Various Methods cont.

The selenium matrix spike/matrix spike duplicate have recoveries above the control limits. The re-analysis yielded a matrix spike recovery within the control limit and a matrix spike duplicate recovery above the control limit. Because the recoveries for the re-analysis were more acceptable, the re-analysis was reported.

Analysis for thallium was performed by graphite furnace in order to achieve detection levles required by the QAPjP.

Inorganics - Various Methods

The Nitrate plus Nitrite laboratory control sample was mis-spiked at 12.5 mg/Kg due to a misinterpretation of the QAPjP.

The matrix spike/matrix spike duplicate recoveries were not calculated due to the sample value being 4 times the concentration of the matrix spike.

There were no other anomalies associated with this report.

Amended

CASE NARRATIVE

QUANTERRA PROJECT NUMBER 077541

General Comments

Only one cooler was received with a temperature blank. The temperature of this blank was recorded at 4.9 degrees Centigrade. The ambient temperatures in the three coolers which samples were received in was recorded as 5.6 degrees Centigrade, 6.4 degrees Centigrade and 6.6 degrees Centigrade.

The pH of the sample in all preserved containers was checked upon receipt and found to be acceptable.

Specialty Explosives by HPLC/MS - Method 8321

The laboratory control sample (LCS) recovered nitroglycerin and PETN above the listed control limits. Presently, the laboratory has not generated enough LCS recovery data to calculate historical limits. Therefore, the control limits used have been designated advisory only. The elevated recoveries in the LCS provide confidence in the analysis ability to detect target analytes at the listed reporting level. Since the samples did not have positive detections of target analytes, the data was accepted.

Semivolatile Organics - Method 8270

The reported duplicate laboratory control sample (DCS) has five compounds with an average recovery above the listed control limits. All of the samples in this project did not have detections of target analytes. The high recoveries in the DCS provide confidence in the analyses ability to detect target analytes at a concentration above the reporting limit.

The sample group was extracted and analyzed with a DCS, as opposed to a MS/SD/LCS, due to limited sample volume.

Due to electronic data deliverable limitations, library search results are available in hardcopy format only.

Amended

Amended

CASE NARRATIVE (continued)

QUANTERRA PROJECT NUMBER 077541

Selected Metals - Various Methods

Analysis for Thallium was performed by Graphite Furnace in order to achieve detection levels required by the QAPjP.

No other anomalies were associated with this report.

Amended

Quanterra

CASE NARRATIVE

QUANTERRA PROJECT NUMBER 077682

General Comments

Temperature blanks were not present upon sample receipt at the laboratory. The ambient temperatures were 2.2 degrees C and 4.1 degrees C.

Semivolatile Organics - Method 8270

The Laboratory Control Sample (LCS) 20SEP94-11A was found to have 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, 1,2-Dichlorobenzene, Hexachloroethane, 2-Nitroaniline, Dimethyl phthalate, and Bis(2-ethylhexyl)phthalate above the control limits.

The Laboratory Control Sample (LCS) 20SEP94-11A was found to have 3-Nitroaniline above the control limits.

These compounds were not detected in the samples, thus no correction action was necessary.

Sample 02960001 (Quanterra ID 077682-009) has 2,4,6-Tribromophenol surrogate recovery above the control limits. The sample was not detected for analytes, thus the no corrective action was necessary.

Due to electronic deliverable limitations, the library search data is available in hardcopy format only.

Specialty Explosives by HPLC/MS - Method 8321

Sample 03140001 (Quanterra ID 077682-012) was re-extracted outside of the analytical holding time due to the initial extraction and analysis resulted in poor chromatography.

The Duplicate Control Sample (DCS) has Tetryl recoveries above the control limit. The sample was not detected for analytes, thus no corrective action was necessary.

Tetryl was above the continuing calibration control limits which was associated with samples 00970001, 01090001, 02660001, 02960001,01130001, and 01200001 (Quanterra IDs 077682-001 thru -011). The end bracketing sample for Tetryl was within the control limits. The samples were subsequesntly re-injected with Tetryl within the control limits.

CASE NARRATIVE - cont.

QUANTERRA PROJECT NUMBER 077682

Selected Metals - Various Methods

- The ICAP method blank (22SEP94-TX) was found to have 5.8 mg/kg of Iron present.

No other anomalies were associated with this report.

Quanterra Environmental Services

CASE NARRATIVE

QUANTERRA PROJECT NUMBER 077730

General Comments

The temperature blank associated with your samples was recorded as 2.1 degrees C.

Semivolatile Organics - Method 8270

The Laboratory Control Sample (LCS) was found o have 3-Nitroaniline above the control limits. There were no positive results found in the samples, thus no corrective actions were necessary.

The Laboratory Control Sample (LCS) has benzoic acid report as NA. The actual value recovery (43%) is within the control limits. Noted in the QAPjP, this compound is flagged for a variance.

Due to electronic deliverable limitations, the library search data is available in hardcopy only.

Selected Metals - Various Methods

Analysis of thallium was performed by graphite furnace in order to achieve detection level required by the QAPjP.

No other anomalies were associated with this report.

Quanterra

QUANTERRA'S QUALITY ASSURANCE PROGRAM

Quanterra has implemented an extensive Quality Assurance (QA) program to ensure the production of scientifically sound, legally defensible data of known documental quality. A key element of this program is Quanterra's Laboratory Control Sample (LCS) system. Controlling lab operations with LCS (as opposed to matrix spike/matrix spike duplicate samples), allows the lab to differentiate between bias as a result of procedural errors versus bias due to matrix effects. The analyst can then identify and implement the appropriate corrective actions at the bench level, without waiting for extensive senior level review or costly and time-consuming sample re-analyses. The LCS program also provides our client with information to assess batch, and overall laboratory performance.

Laboratory Control Samples - (LCS)

Laboratory Control Samples (LCS) are well-characterized, laboratory generated samples used to monitor the laboratory's day-to-day performance of routine analytical methods. The results of the LCS are compared to well-defined laboratory acceptance criteria to determine whether the laboratory system is "in control". Three types of LCS are routinely analyzed: Duplicate Control Samples (DCS), Single Control Samples (SCS), and method blanks. Each of these LCS are described below.

Duplicate Control Samples. A DCS is a well-characterized matrix (blank water, sand, sodium sulfate or celite) which is spiked with certain target parameters and analyzed at approximately 10% of the sample load in order to establish method-specific control limits.

Single Control Samples. An SCS consists of a control matrix that is spiked with surrogate compounds appropriate to the method being used. In cases where no surrogate is available, (e.g. metals or conventional analyses) a single control sample identical to the DCS serves as the control sample. An SCS is prepared for each sample lot. Accuracy is calculated identically to the DCS.

Method Blank Results. A method blank is a laboratory-generated sample which assesses the degree to which laboratory operations and procedures cause false-positive analytical results for your samples.

ATTACHMENT 3

Letter Report on Soil Descriptions
William Lettis and Associates, Inc.

WLA

William Lettis & Associates, Inc.
1000 Broadway, Suite 612, Oakland, California 94607-4041
(510) 832-3716 FAX (510) 832-4139

October 6, 1994

Mr. Erich Thomas
GRAM, Inc.
8500 Menaul Blvd NE, Suite B370
Albuquerque, NM 87112

Re: McCormick Ranch Trench Interpretation

Dear Erich:

As you may recall, William Lettis & Associates provided technical support to Jeff Johnson (GRAM) and Michelle Hedrick (Philips Labs) during their investigation of subsurface conditions at McCormick Ranch.

This letter provides soil and lithologic data collected between September 7 and 12, 1994 in two trenches located near McCormick Ranch (Figure 1). This letter also provides geologic interpretation of surficial deposits at the sites based on trench data and previous field mapping. Soil and lithologic descriptions are provided in Tables 1 and 2. These data were collected and compiled by Christopher Hitchcock and Thomas Sawyer of our office.

Area One: Trench 1.

Area One on McCormick Ranch is located within a small topographic depression in T9N. R3E. Section 36, approximately 1.6 km (1.0 mi) north of South Fence Road and 0.8 km (0.5 mi) west of the western boundary of KAFB (Figure 1). Trench 1 is oriented north-south and is approximately 1.8 m (6 ft) deep, 0.6 m (2 ft) wide, and 4.5 m (15 ft) long. Our observations were made on September 7, 1994, and the trench was closed shortly thereafter.

The deposits within the trench include approximately 1.5 m (5 ft) of fine-grained eolian loess (wind-blown deposits) covering fine alluvial fan gravel of unknown thickness. The eolian loess is a fine clay loam containing scattered, 3 to 5 mm diameter quartzite and granitic pebbles. The underlying alluvial fan gravels contain subrounded, 5 to 10 cm diameter granitic, quartzite, greenstone, and limestone pebbles. The gravel matrix is sand and contains discontinuous pebble lenses. An accumulation of calcium carbonate within the loess forms an approximately 1 m (3 ft) thick whitish-brown horizon at approximately 0.75 m (2.5 ft) depth in the trench (Table 1). The boundary at the base of the carbonate horizon appears to be controlled by the stratigraphic contact between fine-grained eolian loess and underlying gravel. Clasts within the gravel below the carbonate horizon have thin carbonate coats.

The presence of carbonate blocks within the upper part of the trench suggest possible artificial mixing has occurred in the fine-grained loess above the calcium carbonate horizon. Disturbance within the carbonate horizon at the southern end of the trench appears to be related to an east-west trench and coincides with exposed communication wires at 30 cm (1 ft) depth. It is important to note that the presence of the undisturbed calcium carbonate

horizon, which requires at least several tens of thousands of years to form, is an indicator of relative surface stability. This calcium carbonate accumulation also shows that there has been an absence of cultural modification at the depths of the horizon.

The trench is located within a flat area west of the distal edges of a major alluvial fans (Figure 1). Based on our previous geologic mapping and interpretation of deposits exposed within Trench 1, the loess (unit He.mr, Figure 1) covers coarse gravel associated with the western edge of a late Pleistocene fan (unit PF3.1m) derived from the Manzano Mountains to the east. The gravel deposit most likely thins to the west and becomes finer-grained. The loess likely is associated with nearby late Quaternary dune deposits that cover the alluvial fan deposits. The thickness of the loess probably varies depending on surface topography and the presence or absence of dune deposits.

Area Three: Trench 4.

Area Three is located within a small topographic depression north of a large playa on McCormick Ranch, approximately 1.1 km (0.7 mi) north of South Fence Road and 1.2 km (0.75 mi) west of the western boundary of KAFB. Trench 4 is oriented east-west and is approximately 0.8 m (6 ft) deep, 0.6 m (2 ft) wide, and 4.5 m (15 ft) long. The deposits exposed in this trench were noticeably damper than those exposed in trench 1 at Area One. Our observations were made on September 12, 1994, and the trench was closed shortly thereafter.

The deposits within trench 4 consist of dark-brown, silty, fine-grained playa deposits less than 0.7 meter thick. These deposits overlie light-brown, sandy, fine-grained eolian loess of unknown thickness. The playa deposits are organic silty clay containing 1 to 5 mm subrounded quartzite pebbles. The eolian loess is loamy sand containing minor (<1% total volume), 1 to 5 mm diameter, sub-rounded to well-rounded quartzite and granitic pebbles. Weak accumulation of calcium carbonate forms an approximately 0.5 m (1.5 ft) thick whitish-brown horizon at approximately 1.2 m (4 ft) depth in the trench (Table 2). Within the eolian loess, thin carbonate coats are present on the bottoms of pebbles, showing that the soil contains an alkali pH. As in trench 3, the presence of the undisturbed calcium carbonate horizon is an indicator of relative surface stability over a period of at least several tens of thousands of years. This calcium carbonate accumulation also shows that there has been an absence of cultural modification at the depths of the horizon.

The upper 60 cm (2 ft) of the trench exposed artificial fill, based on the presence of discolored blocks and mixing. Roots are present to approximately 1 m (3 ft) depth. Minor amounts of bioturbation are illustrated by evidence of animal burrows within deposits exposed to the bottom of the trench.

Area Three is a small playa developed within eolian loess deposits. The thin playa deposits overlying eolian deposits exposed in trench 4 probably are laterally discontinuous and may be confined within the topographic depression of Area Three. The presence of scattered pebbles suggests that the eolian, and possibly playa, deposits have been reworked by fluvial processes. The absence of alluvial fan gravel within trench 4 does not exclude the possibility that alluvial gravels may be encountered at depths greater than the trench. Area Three is west of the mapped western edge of the late Pleistocene alluvial fan identified in Area One, and therefore may have a thicker section of eolian loess covering alluvial fan gravels.

We hope that these data and interpretations are useful to the evaluation of the trench stratigraphy and to the assessment of cultural features in the area. We appreciate having the opportunity to view the trenches and would appreciate being notified if any other excavations are planned. Please feel free to call if there are any questions, or if we can be of further assistance.

Sincerely,

Christopher S. Hitchcock
Senior Staff Geologist

Keith I. Kelson
Senior Geologist

Attachments: 2 tables, 1 figure

cc: J. Johnson (GRAM)
M. Hedrick (Philips)
1057 file

Table 1. Soil-profile description, Trench 1, Area One, near McCormick Ranch, New Mexico. Soils were described according to the standards of the Soil Survey Staff. Color descriptive terms refer to Munsell color charts.

Area One: Trench 1 Profile

Date open: 7 September 1994
Location: McCormick Ranch. T9N. R3E., middle of Section 36.
Elevation: 5270'
Vegetation: Sparse grass with scattered sagebrush.

Ap 0-20 cm, dark yellowish brown (10YR4/4 (dry), 10YR3/4 (moist) fine silty loam. Slightly sticky, slightly plastic; non-gravelly, fine roots.

Akj 20-34 cm, dark yellowish brown (10YR4/6 (dry), 10YR3/6 (moist)) fine silty loam. Very slightly sticky, very slightly plastic; fine sub-rounded gravel less than 1% of total volume; fine angular blocky structure; gradual, smooth lower boundary.

Bw 34-60 cm, light yellowish brown (10YR6/4-6 (dry), 10YR6-5/4 (moist)) fine sandy loam. Very slightly sticky, very slightly plastic; fine sub-rounded gravel less than 1% of total volume; medium angular blocky structure; gradual, wavy lower boundary.

Bk1 60-99 cm, light gray (10YR7/2 (dry), 10YR6/4 (moist)) fine sandy loam. Slightly sticky, slightly plastic; fine sub-rounded gravel less than 1% of total volume; coarse angular blocky structure; diffuse, wavy lower boundary.

Bk2 99-145 cm, light gray (10YR7/2 (dry), 10YR6/2 (moist)) fine sandy loam. Slightly sticky, slightly plastic; fine sub-rounded gravel less than 1% of total volume; fine angular blocky structure; clear, smooth lower boundary.

2Bk3 145-165+ cm, light yellowish brown (10YR6/4 (dry), 10YR5/4 (moist) fine loam. Slightly sticky, slightly plastic; medium to coarse rounded gravel.

Table 2. Soil-profile description, Trench 4, Area Three on McCormick Ranch, New Mexico. Soils were described according to the standards of the Soil Survey Staff. Color descriptive terms refer to Munsell color charts.

Area Three: Trench 4 Profile

Date open:	12 September 1994
Location:	McCormick Ranch. T9N. R3E. southwest corner of Section 36.
Elevation:	5257 ft
Vegetation:	Sparse grass with scattered sagebrush.

Fill 0-59 cm, fill, no description, abrupt lower boundary.

A 59-71 cm, dark yellowish brown (10YR 4/4 (moist)) silty clay. Sticky, plastic; fine sub-rounded gravel less than 1% of total volume; massive structure; gradual, smooth lower boundary.

2Bw 71-102 cm, strong brown (7.5YR 5/6 (moist)) loamy sand. Not sticky, slightly plastic; fine sub-rounded gravel less than 1% of total volume; massive structure; gradual, smooth lower boundary.

3Bk1 102-125 cm, pink (7.5YR 7/4 (moist)) clay loam. Sticky, plastic; fine sub-rounded gravel less than 1% of total volume; fine subangular blocky structure; gradual, smooth lower boundary.

3Bk2 125-170 cm, pink (7.5YR 7/4 (moist)) clay loam. Slightly sticky,-plastic; fine sub-rounded gravel less than 1% of total volume; medium platy to angular block structure, Gradual, irregular lower boundary.

3BC 170-203+ cm, light brown (7.5YR 6/4 (moist)) clay loam. Sticky, plastic; fine sub-rounded gravel less than 1% of total volume; medium angular blocky structure.

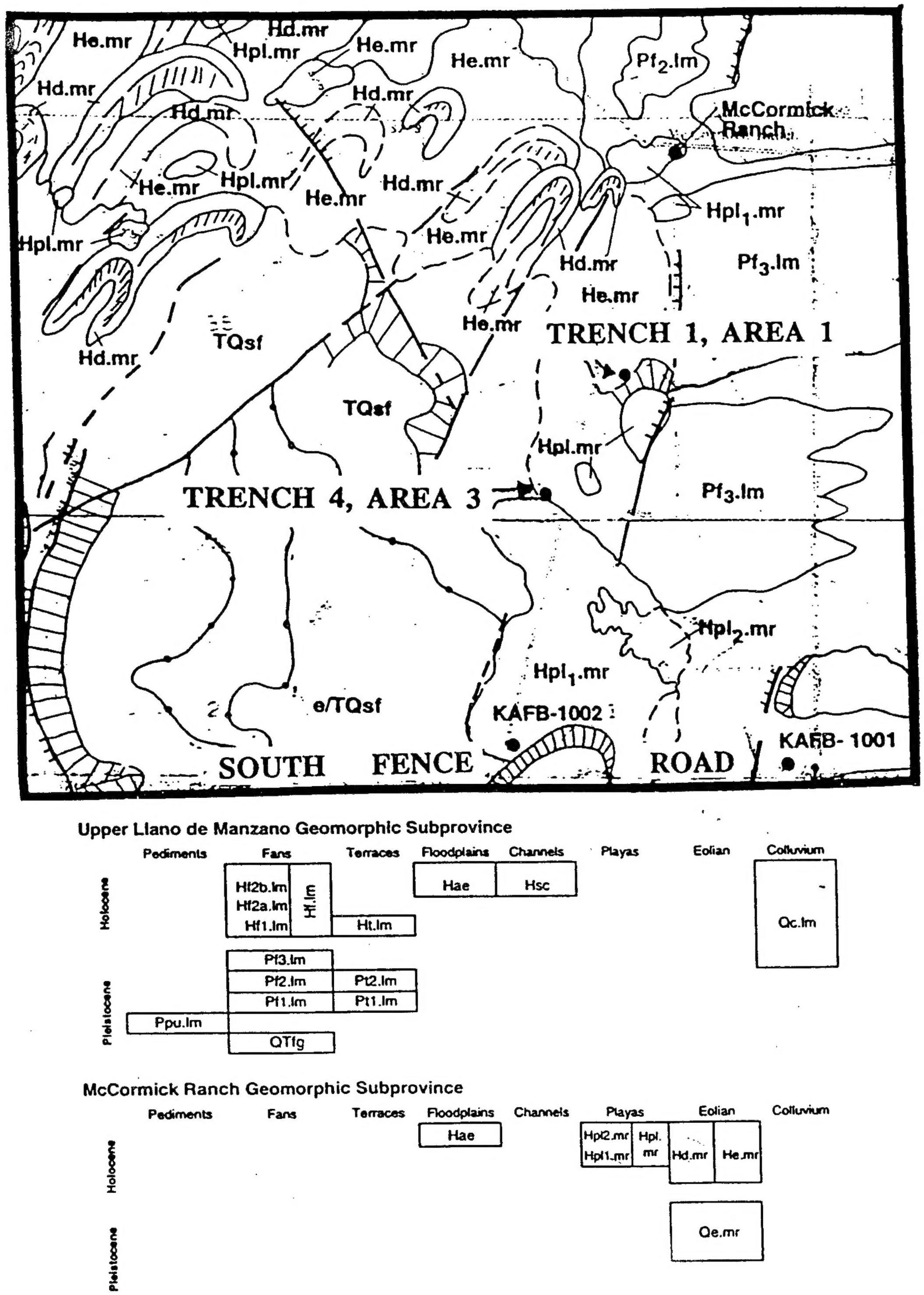

Figure 1: Surficial geologic map showing locations of McCormick Ranch trenches.